CRANFIELD UNIVERSITY

Peter William Burr

# The financial costs of delivering rural water and sanitation services in lower-income countries

School of Applied Sciences

PhD
Academic Year: 2014 - 2015

Supervisor: Dr Richard Franceys
October 2014

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# ABSTRACT

Despite the impressive progress over the last two decades in which millions of people worldwide have gained first time access to improved water and sanitation infrastructure, the reality for many is that shortly after infrastructure construction the actual service received by users slips back to unacceptably low levels. However, due to inadequate research and inconsistencies with how data and cost data has been collected and reported, very little is known of the necessary levels of expenditure required to sustain an acceptable (so called "basic") water and sanitation service and this inhibits effective financial planning for households, communities, governments and donors alike.

This thesis sought to provide a better understanding of what has historically been spent to provide different levels of water and sanitation services as a means to better understand the necessary expenditure required. Empirical findings are based on a large data sample of nearly 2,000 water points, over 4,000 latrines, and over 12,000 household surveys, which have been collected as part of three research projects (WASHCost, Triple-S, and WASHCost Sierra Leone), across five country research areas (Andhra Pradesh (India), Burkina Faso, Ghana, Mozambique, and Sierra Leone).

Findings for water supply systems show that the combination of high capital investments of: $19 and $69 per person for community point sources and $33 – $216 per person for piped systems; and low recurrent expenditures of: $0.06 - $0.37 per person per year for point sources and $0.58 - $7.87 per person per year for piped systems; results in less than half of users receiving a "basic" level of service. Evidence based estimates of the required expenditure for acceptable services are found to be far greater than the "effective demand" expressed in terms of the willingness to pay of service users and national government for these services.

Findings for sanitation show that constructing a household latrine that achieves "basic" service standards requires a financial investment of at least $40 that is likely to be an unaffordable barrier for many households in lower income

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countries. In addition the costs and affordability of periodic pit emptying remains a concern.

Ultimately this research suggests that if international standard of improved water and sanitation services are to be sustained in rural areas, the international sector will likely have to provide additional investments to meet a significant proportion of the recurrent costs of delivering these services.

Keywords:

Sustainability, Service Levels, Expenditure, Latrines, Maintenance, Capital Maintenance, Small Town, Financing, India, Burkina Faso, Mozambique, Ghana, Sierra Leone

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# ACKNOWLEDGEMENTS

This thesis would not have been possible without the committed, capable and inspiring work of the WASHCost team without whom this thesis would not have been possible. In particular I want to thank Dr. Catarina Fonseca for mentoring me with warmth and enthusiasm throughout project and giving me the opportunity and responsibility to work in these incredible countries, and with these incredible people. Speaking of which! A special thank you to Dr. Snehalatha Mekala, Dr. Kwabena Nyarko, Arjen Naafs, Dr. Christelle Pezon, Julia Zita, Richard Bassono, Amélie Dubé, Bismark Dwumfour-Asare, and Anitha Raj; for putting up with my incessant questioning with good humour and open mind.

From Cranfield, I am very grateful to my supervisor Dr. Richard Franceys for steering me past the many and varied curveballs that the PhD process throws at you and for his constant supply of insightful comments; and also to my second supervisor Dr. Alireza Daneshkha for his expertise and support on the statistical components of the analysis.

Finally, a massive thank you to all my friends and family for your love and support throughout and of course to my wife Janey for putting up with me! I promise we will now get our weekends back!

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| BH and HP | Borehole and Handpump |
| CapEx | Capital Expenditure |
| CapManEx | Capital Maintenance Expenditure |
| CLTS | Community Led Total Sanitation |
| CoC | Cost of Capital |
| COM | Community Ownership and Management |
| CWSA | Community Water and Sanitation Agency |
| DA | District Assembly |
| DACF | District Assembly Common Fund |
| DANS | Data Archiving and Network Services |
| DFID | Department of International Development (UK) |
| DiMES | District Monitoring and Evaluation Systems |
| DWST | District Water and Sanitation Team |
| EHA | Environmental Health Assistants |
| ExpDS | Expenditure on Direct Support |
| ExpIDS | Expenditure on Indirect Support |
| GASB | Governmental Accounting Standards Board (USA) |
| GDP | Gross Domestic Product |
| GLASS | Global Analysis of Sanitation and Drinking Water |
| HDW and HP | Hand Dug Well and Handpump |
| IFC | Infrastructure Renewals Charge |
| IPL | Improved Pit Latrines |
| IRC | IRC: International Water and Sanitation Centre |
| IT | Information Technology |
| JMP | Joint Monitoring Programme |
| LPCD | Litres Per Capita Per Day |
| MDG | Millennium Development Goals |
| Mech BH | Mechanised Borehole System |
| MPS | Mixed Piped Supply |
| MTDP | Medium Term Development Plan |
| MTS | Multi-Town System |
| NGO | Non-Governmental Organisation |
| Ofwat | Water services and Regulation Authority |
| OpEx | Operation and Minor Maintenance Expenditure |
| PF | Pour Flush Latrines |
| RWSN | Rural Water and Sanitation Network |

| | |
|---|---|
| SDA | Service Delivery Approach |
| SINAS | National Information System for Water and Sanitation |
| Std. Dev, | Standard Deviation |
| STS | Single-Town System |
| TPL | Traditional Pit Latrines |
| UN | United Nations |
| US$ | United States Dollar |
| VIP | Ventilated Improved Pit Latrines |
| WATSAN | Water and Sanitation Management Teams |
| WHO | World Health Organisation |
| WSDB | Water and Sanitation Development Board |
| WSP | Water and Sanitation Programme |

# 1 Introduction

## 1.1 Background to the study

The genesis of this study was the apparently simple question from a potential donor new to the sector: what does it cost to provide people with acceptable and sustained water and sanitation services?

However this was not a question that the sector found easy to answer. The donor found that quantifying the cost of delivering services is complex and immediately raises additional questions as to: whether and to what extent the cost relates to initial costs of investment or the ongoing costs of sustainability? What is understood as an acceptable ("basic[1]") level of service and how can this be measured? What costs are being paid currently and by whom? Are these payments sufficient to sustain existing levels of service? And are these levels of services in line with what is considered "improved" by the sector, as codified in the Millennium Development Goals for water and sanitation?

Beyond the conceptual challenge of understanding how to quantify costs and services, there is also the practical challenge of accessing cost data in a sector where the majority of development finance is focussed on the capital costs of infrastructure construction, without accounting for or documenting the ongoing costs of service management, maintenance and rehabilitation (Fonseca and Cardone, 2005). There is also the common challenge of country contexts where resources are often constrained, and robust systems of documentation and monitoring are often not in place.

The donor in question, the Bill and Melinda Gates Foundation, responded to these gaps in sector knowledge by funding the WASHCost project hosted by the International Water and Sanitation Centre (IRC) in The Hague. Over a period of five years (2008-2013), and with a budget of $14.5 million, the WASHCost project developed a methodology to collect and analyse data on financial costs of water

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1 Throughout this thesis a "basic" level of water or sanitation service is understood as the lowest level of acceptable service that system users can receive as defined by the WASHCost service ladder frameworks. These are outlined in detail in section 3.7.1.

and sanitation services, and executed large scale data collection across hundreds of sites in Andhra Pradesh (India[2]), Burkina Faso, Ghana and Mozambique. The aim of the project was to provide the sector with accurate, disaggregated, and globally relevant data, able to inform sector investment decision making. It involved researching the levels of existing expenditure and service delivery as a first step, to then research the costs of providing sustained and improved services. WASHCost was focussed on quantifying the financial costs of providing services and therefore any non-monetary costs, opportunity costs, or the wider economic costs of not having access to water and sanitation services were not systematically collected.

This thesis is a product of the WASHCost research project and it presents the cross-country analysis quantifying the costs of providing water and sanitation services in four WASHCost study areas. This core dataset is also bolstered by additional cost data collected in a fifth country, Sierra Leone, as part of a follow-on project to WASHCost.

Furthermore, additional case study work was undertaken in two rural districts of Ghana as part of the "Sustainable Services at Scale" (Triple-S) project – a sister project to WASHCost hosted at the IRC. This detailed case study analysis enabled a deeper, more context specific understanding of the costs for providing and sustaining rural water supply services.

The role of the researcher in these different projects is fully explained in section 1.3. In addition the different methodologies at the different stages of the study are discussed in sections 3.5 and 3.6.

## 1.2 Sustaining water and sanitation systems in lower-income countries

Considerable investment in water and sanitation infrastructure over the last two decades has seen more than two billion people gain access to improved drinking

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[2] Throughout this thesis the phrase "country" studies refers to the country units of study as well as the study in one state (Andhra Pradesh) of India. Subsequent to data collection and analysis as a result of the 2014 "Andhra Pradesh Reorganisation Act", Andhra Pradesh has been bifurcated into two states Telenganga and residuary Andhra Pradesh.

water sources (WHO/UNICEF, 2012) and 1.9 billion people gain access to improved sanitation facilities (WHO/UNICEF, 2010). However, despite these increases in nominal coverage rates, for many people in lower-income countries, and particularly for those living in rural areas, existing water and sanitation systems remain unreliable, inadequate, and often provide unacceptable standards of service.

At any given moment global estimates suggest that between 30%–40% of rural water supply systems in developing countries are not working (RWSN, 2010; Baumann, 2006; Evans, 1992) and in some areas non-functionality rates have been found as high as 70% and 80% (Mackintosh and Colvin, 2003; Skinner, 2009). This rate of failure is not limited to breakdown of old systems In rural Tanzania 25% of rural point source systems were found to be broken down within two years of construction (Haysom, 2006).

In the case of sanitation, the known health benefits of latrine ownership and usage are proving poor motivators for sustained behaviour change in rural communities (Cairncross and Valdmanis, 2006). In Northern Ghana, Rodgers et al., (2007) found that 60% of households with an improved larine were using it. Similarly a review of villages that had been declared “open defecation free” in found that 33% of households had reverted back to open defecation and more than 70% of latrines were no longer considered to be “fully functional” (CMS, 2011).

Together these studies demonstrate that the failure to track indicators of ongoing functionally, condition and use of water and sanitation facilities means that in many lower-income countries the actual levels of water and sanitation coverage are likely to be significantly lower than those reported by the Joint Monitoring Programme of the Millennium Development Goals (Cotton and Bartram, 2008). The costs reported therefore are not necessarily the costs of achieving ongoing improved or sustained services.

Low levels of “functional sustainability[3]”of infrastructure in the sector has led academics and practitioners alike to evaluate the ingredients of a sustainable service delivery (Montgomery et al., 2009; Harvey and Reed, 2004; Lockwood et al., 2003; Parry-Jones et al., 2001; DFID, 2001; Carter et al., 1999). These studies all emphasise the complexity inherent in rural service delivery and contend that the functionality outcomes are conditioned by numerous inter-dependent governance, technical, financial, and socio-economic factors, some of which are relevant at community level, others at meso-levels (district) and others still at national and international levels. However, as Parry Jones et al., (2001) illustrate “financing” and “maintenance” factors should be considered to be the heart of all these factors as these are the ones that directly impact on infrastructure sustainability.

In recent years multi-national discussions of the post-2015 global development goals have acknowledged these issues. Discussion of the post-2015 indicators at the UN recognised that “more focus must now be put on spending for operation and maintenance necessary for the sustainability of services from both existing and new infrastructure” (UN-Water 2014). Similarly the UN Global Analysis of Sanitation and Drinking Water (GLASS) report stressed that unless urgent attention is given to maintaining existing services, there is a “significant risk of slippage” of rates of coverage amongst lower-income countries (WHO, 2012). Doczi et al. (2013) argue that increasing the levels of recurrent expenditure should be a global policy imperative.

Historically the sector has tended to “grossly underestimate” these recurrent costs (Fonseca and Cardone, 2005) which have remained largely hidden from financial planning processes (Hutton and Bartram, 2008). In part this is symptomatic of a knowledge gap as it is unclear to financiers as to which costs need to be financed and by whom (Toubkiss, 2006; Lockwood and Smits, 2011). It is also reflective of a data gap, as systematic cost data has not been collected in rural areas where data is often dispersed amongst several sector agencies

[3] Defined by Carter et al., (1999) as systems which are continuing to work and delivering service benefits over time.

making it expensive to collect, of varying quantity and quality, and hard to attribute to services delivered (WHO, 2012).

Development finance for water and sanitation systems is still predominantly focussed on capital expenditure to the extent that just 7% of external investment in the sector is being targeted at maintaining existing systems (WHO, 2012). Furthermore within developing countries, the tracking of public expenditure flows has also shown that even basic maintenance of water and sanitation infrastructure is seriously underfunded (Van Ginneken et al. 2011).

Hutton and Bartram (2008) estimate that 75% of the financing shortfall for water and sanitation relates to the recurrent costs of operation and maintenance, monitoring and education. However, in the absence of country specific data it is impossible to accurately understand the magnitude of any financing deficit and its impact on the services received by users. The expectation is that more informed evidence and discussion on the long – term costs of delivering water and sanitation services can help inform better financial and investment planning amongst donors, governments, and households alike.

This thesis evaluates service delivery costs and financial planning in a variety of ways. It seeks to contribute to overall sector knowledge by reporting on a detailed cross-country analysis stakeholder expenditure on constructing and maintaining water and sanitation systems compared to the related level of service received by users. Further analysis then evaluates the relationships between the type and cost water or sanitation technologies and the service received by users. It assess the effectiveness of existing sector spending across different country contexts to furthermore to provide insights into the sufficiency of current levels of expenditure, and the relative cost effectiveness of different technology choices.

The final component of this thesis provides a case study analysis of costs, functionality and management of rural water supply systems in two rural districts of Ghana, to better understand the inter-relationship between these factors and inform more detailed cost analysis.

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It is acknowledged by donors that a more systematic approach is needed to understand the cost of delivering water and sanitation services over time (DFID, 2012). This can in turn help all stakeholders make more informed choices on levels of service and technologies, and develop more effective management and financing strategies (Willetts et al, 2012; Harvey, 2007).

The remainder of this chapter describes the context of the thesis in relation to the WASHCost research project, explains and justifies how rural areas are defined throughout the study, summarises the identified knowledge gaps, and lays out the research aim and key research questions addressed. The chapter concludes by outlining the structure of the remaining thesis chapters.

## 1.3 Data sources and the role of the researcher

The main bulk of the findings contained in this thesis were collected and analysed within the scope of the WASHCost project. The primary research undertaken by WASHCost was carried out by national staff in each of the four research countries. The researcher was the key researcher in the fifth “global” team based in the Netherlands, which was responsible for the overall project management of the entire research process and also for the collation, validation, and analysis of data for cross-country comparison. In addition to the WASHCost data, this thesis includes findings from additional research carried out in Sierra Leone and from field work undertaken in two rural districts of Ghana. These supplementary research elements are reflective of opportunities pursued by the researcher to replicate and extend the WASHCost methodology into new study areas. These activities are briefly outlined below and in further detail in the methodology section.

In Sierra Leone the researcher was the research lead on a DFID funded project running from 2013 to 2014 which replicated the WASHCost data collection and analysis methodology across three rural districts. The Sierra Leone data has been analysed in conjunction with the core WASHCost data – ensuring that the cost analysis can be made across 5 countries. In Ghana, the researcher spent a month undertaking data collection and analysis in two rural districts as part of the “Sustainable Service at Scale” (Triple-S) project. Triple-S actively builds upon the work of WASHCost and is a large multi-country project, financed by the Gates Foundation and executed by IRC[4]. One aspect of the work of Triple-S in Ghana has been the creation of asset inventories of rural water systems, detailing information on system functionality, performance, and repair costs. Working alongside district council staff, the researcher used this data to evaluate how this detailed, context specific information could inform a deeper understanding of rural service delivery costs, and be utilised to improve financial decision making at community and local government levels.

The IRC/WASHCost project was the non-academic collaborator in this research. This allowed the researcher to work closely with country staff in each of the project countries as well as being a key research focal point within the "global" team. Further details on these projects and their relationship to this research are discussed in section 3.1.

The WASHCost project examined both water and sanitation systems, as does this thesis. However as the doctorate and the research process evolved, there was a conscious narrowing of focus to the issues of water supply in small rural communities. This choice is reflected throughout the literature, findings, discussion, and conclusion.

## 1.4 Defining the boundaries of "rural"

This thesis examines various water and sanitation technologies and service delivery approaches from numerous lower-income countries in what are locally defined as rural areas. Rural areas are often defined in the counterfactual, i.e. a rural area is seen as everywhere that is not urban or part of the so-called "urban agglomeration" (UN, 2004). This boundary may not be determined by any objective measure, rather, as Danert and Flowers (2012) report, the difference between urban and rural often comes down to where administrative boundaries have been drawn between municipal (city) councils and everywhere else

[4] The WASHCost approach to costing water systems was identified as one of the ten key building blocks of sustainable water services by the "Sustainable Services at Scale" project. Furhter information on these aims, as well as the wider goals of "Triple-S" can be found at: http://www.waterservicesthatlast.org/

administered by “rural” district councils. The reality, they argue (and also accepted by this thesis), is that the divide between rural and urban is not distinct and within most countries there is a blurred continuum of “ruralness” from hamlets and small communities, to small towns and rural growth points, and finally secondary cities and municipal centres (Danert and Flowers, 2012).

Where a community lies on the rural continuum has implications for service delivery. For example, small scale piped water systems with standpipes and some household connections have become synonymous with service delivery in small towns, and the service delivery challenges are considered to be distinct from “truly rural” small communities that are served by point source systems (Adank 2013; Pilgrim et al. 2007). However, it is also recognised that definitions of “rural communities” and “small towns” are not uniform in all contexts. This research found for example, that what is locally defined as a small “rural” community in India shares many characteristics in terms of population, density, and type of water supply as those termed small towns in the African context.

This thesis recognises the heterogeneity of rural areas within and between countries and also acknowledges the associated problems this has for understanding and comparing asset systems according to local definitions. Consequently, for water services, cross-country comparisons were made according to two criteria: the type of water supply system (the “technology”) and the number of people served by the system, or combination of systems (“the service area”).

Therefore the areas served by a piped supply, that covers most households, are described as “small towns,” and those with only point source systems are described as “rural communities”. In terms of sanitation, all the latrines sampled were “on-site” systems and not connected to a sewerage network. Distinctions were drawn between the types of “on-site” technology based on their characteristics (namely faecal storage, faecal separation, flushing, and ventilation). Comparisons were also made between latrines in rural and small town areas as per the definition used in the water analysis. Definitions of the technologies used in this thesis are given in section 3.4.

## 1.5 Knowledge gaps

This background analysis has highlighted that in rural areas of lower-income countries there has been insufficient empirical research into the magnitude and sufficiency of existing expenditure on constructing (capital expenditure) and sustaining (recurrent expenditure) water and sanitation services. Research needs to focus on:

- Comparable evidence of scale and variability of disaggregated expenditure on water and sanitation systems between countries, between technologies and also in the same country using the comparable water and sanitation technologies.
- The impact that expenditure on different unit costs has on the standard of services delivered.
- An understanding of what necessary unit cost expenditure is required to ensure the sustained delivery of improved services and how this compares with existing expenditure.

## 1.6 Research aim

The long-term aim of this research project is to improve the sustainability of rural water and sanitation services in lower-income countries through more informed and effective financial planning and management.

## 1.7 Research objectives

***Research Objective 1:*** *Determine what has historically been spent on providing different levels of water and sanitation service, using Burkina Faso, Ghana, India, Mozambique and Sierra Leone as examples.*

**Sub objective 1.1:** Provide the sector with *a country by country* analysis of the historical costs of providing services through *different* water and sanitation technologies in rural communities and small town areas.

**Sub objective 1.2:** Provide the sector with a *cross-country* analysis of the historical costs of providing services through *comparable* water and sanitation technologies.

**Sub objective 1.3:** To provide insight in how effective sector expenditure has been in delivering adequate water and sanitation services, as opposed to simply coverage.

**Sub-objective 1.4:** Assess the effect of expenditure, technology and country context on water and sanitation service levels.

***Research Objective 2:*** *To provide guideline data on the necessary levels of capital and recurrent expenditure required to improve the sustainability of water and sanitation services*

**Sub objective 2.1:** To undertake a general assessment of the necessary expenditure required to sustain water and sanitation systems based on WASHCost data on costs and service levels from five countries.

**Sub objective 2.2:** To undertake a specific assessment of the necessary expenditure required to sustain water services in rural Ghana based on a comprehensive inventory of asset functionality, management, and financing arrangements in two districts.

**Sub-objective 2.3:** To assess the impact of current management and financing practices at community and district levels on the functionality of rural water points in Ghana.

The conceptual framework crystallising the research aim and these objectives is finalised at the end of Chapter 2 following the literature review and detailed consideration of the research gap.

## 1.8 Structure of thesis

This thesis is divided into seven chapters. Chapter 1 introduces the background, scope, aims, and objectives of the research. Chapter 2 provides a critical analysis of the background literature relating to the main research objectives as highlighted above. Chapter 3 outlines the different data collection and analysis methodologies employed at different phases of the research process. Chapter 4 evaluates the historical life-cycle expenditure on sanitation services in five low/middle income countries. Chapter 5 evaluates the historical life-cycle

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expenditure on water services in five low/middle income countries. Chapter 6 provides an in depth analysis of the adequacy of current expenditure on rural water supply in two districts of Ghana. Chapter 7 synthesizes the findings of the research and suggests avenues for future research.

# 2 Literature review

## 2.1 Introduction

This chapter provides an analysis of the background literature relating to the main research objectives introduced in Chapter 1. Specifically the literature review evaluates the main knowledge gaps, and summarises relevant key concepts, in three stages:

1) Assessment of the key terminology used to define and analyse the financial costs of water and sanitation service delivery, in particular examining how these relate to rural and small town service delivery in lower-income countries;
2) Critical analysis of available academic and sector literature relating to the identified unit costs of providing and sustaining water and sanitation services in rural areas of lower-countries.
3) Appraisal of the key academic literature relating to the health and livelihood benefits of water and sanitation services and critically analyse how these relate to global standards and methodologies of how to monitor and measure improved services.

A fourth descriptive section is shown in Appendix A and provides an historical overview of the trends in water and sanitation service delivery over the last thirty years, including a discussion of how perspectives and approaches to sustainability have changed during this time.

## 2.2 Defining the financial costs of water and sanitation systems

This section provides an assessment of how the financial costs of constructing, operating and maintaining water and sanitation systems are defined and categorised in the sector.

Throughout the literature distinctions can be drawn between the costs of constructing water and sanitation systems and the recurrent costs of maintaining them. Ellam and Sierferd (1998) term these two groupings as the costs




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associated with acquiring infrastructure and the costs associated with owning infrastructure.

In an evaluation of the costs associated with small town community water systems Jagals and Rietveld (2011) draw similar distinctions. The costs of infrastructure construction are termed capital costs and defined as the “total construction costs that are not expected to recur for some time” (Table 2-1). This therefore includes infrastructure that relates directly to the delivery of services such as “equipment” (pumps and power systems), and fixed installations (below ground pipes dams and reservoirs), as well as other buildings associated with the administration and management of the system. The costs of “owning” the system are termed recurrent costs (Table 2-2), and include the direct costs of maintaining the system (tools, spares, and equipment), as well as the operational costs of running the system (the costs of staff time and paying for the energy power the system). In this formulation recurrent costs also include “fixed costs”, which are defined as the obligation to account for the eventual cost of financing the replacement of the system by depreciating the different components of the system by an appropriate expected lifespan.

**Table 2-1: Disaggregation of capital costs**

| **Components of capital costs** | **Activity** |
|---|---|
| Preliminary studies | Evaluation of the technical, economic , social, environmental, and health aspects of the project |
| Fixed installations (system) | Pipes, clean water reservoirs, filter units |
| Fixed installations (operation and management) | Office, sanitary facilities, new treatment facilities etc… Furnishings for these facilities |
| Equipment | Pumps, power systems |
| Materials | All materials bought locally or internationally |
| Workforce | Engineers, technical staff, social science professionals as well a semi-skilled community labour |
| Other | Management of the project, administration, logistics, transportation, communication |
| Acquisition of land | Sites for treatment facility, offices |

**Table 2-2: Disaggregation of recurrent costs**

| Components of recurrent costs | Activity |
|---|---|
| Maintenance costs | All costs for repair and replacements of part/all of the system within predicted life of the system |
| Operational costs | Employing staff. Purchase of consumables: energy, process water, chemical, waste disposal |
| Fixed costs | Obligations to finance the replacement of the system including: depreciation charge, interest on loans etc... |
| Monitoring, surveillance and training | Activities to assess and maintain water quality at source and treatment and provide training to staff |

Source for Table 2-1 and: adapted from Jagals and Rietveld, 2011

Similar but nevertheless distinct cost definitions and terminologies are widely used within accounting and financing strategies for the management of water and sanitation in developed countries and for urban utilities,

The Water Service Regulation Authority (Ofwat) is the economic regulator of private water companies in the UK, and has been at the forefront of developing the terminology and methodologies to understand unit costs. This has been driven by the need to develop regulatory accounting guidelines that deliver a consistent framework for defining and reporting costs which allows comparability between service providers. A similar accounting approach, driven by a similar need for transparency in decision making over costs and pricing, are being recommended as part of regulation of private sector participation contracts for water and sanitation utilities in developing countries (see for example: Shugart and Alexander, 2009).

Central to the Ofwat approach is the conceptualisation of the relationship between costs and services. Ofwat monitors and evaluates the performance of private water and wastewater companies according to the level of “serviceability” they provide to customers (Ofwat, 2011, Parsons, 2006). Serviceability refers to the “capability of a system of assets to deliver a reference level of service to customers and to the environment now and into the future” (Ofwat, 2011). Indicators that are used for comparison include both measures of technical performance as well as a series of customer satisfaction indicators (UKWIR, 2006).

This approach means that the costs of the water and wastewater systems are understood, calculated, and assessed in terms of the entire costs incurred. This contributes to the level of service being provided, rather than the cost associated with a particular technology or asset. The total “service cost” is therefore defined as:

*The sum of the functional costs for each of the service activities, plus the sum of the appropriate portions of the functional expenditures of the individually identified business activities, plus the appropriate portions of the costs of rates, doubtful debts, exceptional items, the write-off of intangible assets, and of general & support costs* (Ofwat, 2007).

These costs can be unpacked further into the costs of “operation” and the costs of “capital maintenance” (Ofwat, 2005). Operating costs comprised of those activities directly related to the delivery of water and sanitation services (such as water treatment, or sanitation treatment or disposal), and a broader group of activities including “direct costs” (such as salaries, power, bulk water charges); “general support costs”, and “customer service” expenditure, which are concerned with how the water company is operating as a business.

“Capital maintenance” (CapManEx) is understood as “the planned activities to replace and renovate water and sewerage assets to provide continuing services to consumers” (Ofwat, 2008). The costs of undertaking the planned activities are calculated in two different ways depending on the type of asset being considered. The expected CapManEx, for below ground “infrastructure” assets such as water mains and sewerage networks, is derived according to the infrastructure renewals charge (IFC). This charge is calculated through an assessment of the expected costs of maintaining a “defined standard of service and repair” (CICA, 1989) of an asset over the medium to long term (typically understood as in excess of 15 years).

For above ground (or tangible) assets, capital maintenance costs are calculated by using a current-costs accounting approach. On an ongoing basis therefore, tangible assets are re-valued at their current cost by assessing the estimated costs of purchasing "modern equivalent asset" of same condition and capacity (Ofwat, 2011). This approach negates the impacts of inflation on the value of the asset (a recognised failing of historic cost accounting approaches), with the changes in the falling (depreciating) value of the asset charged as a cost to financial accounts. This approach means that even when inflationary pressures are high, sufficient funds are still being set aside to renew assets when required

Elsewhere, the Governmental Accounting Standards Board (GASB) in the USA recognise two different approaches for states and local govenrment service providers to account for costs of assets over time. The first simplistic approach is to depreciate an asset from original purchase cost – this is termed "historic costs accounting" and does not take in to account inflationary effects and involves little ongoing asset montoring. The second approach requires a level of asset monitoring to measure the condition and performance of system assets over time. This data is then used to asses the maintenance costs of bringing the asset back to a reference condition level (GASB, 1999), this is termed as estimating the cost of "deferred maintenance" – maintenance that has not taken place when it was scheduled, or required (FASAB, 1996).

In an assessment of different asset accounting approached worldwide, Walker and Jones (2012), found that infrastructure managers in Australia "overwhelmingly preferred information about the physical condition of assets, combined with estimates of the current cost of bringing those assets to a satisfactory condition". They agreed that financial statements being supplemented by estimates of the cost of achieving serviceability, or, as they term it "deferred maintenance," are considered as more useful than a fixed depreciation charge. In a similar vein, Harris (1999) argues that accounting models, that depreciate asset by an estimated useful lifespan, carry significant uncertainty, as lifespans that are not linked to the condition performance of the asset can be a fairly arbitrary measure of asset value.

In urban areas the reporting, monitoring, and benchmark of performance and financial data is becoming more wide-spread. IB-NET for example draws together utility information from over 4,500 utilities from more than 130 countries and territories (IBNET, 2014). For financial analysis and benchmarking they track indicators of operation and maintenance costs and depreciated asset values overtime. The primary measure used to benchmark financial performance is the comparison of operational and maintenance costs (excluding depreciation) with operating revenue from customers, and this is done alongside other benchmark measures of technical and service performance.

This sub-section has shown that the ways to define, classify, and account for the capital and recurrent costs of water and sanitation system can vary between different contexts and accounting approaches. However in each case the calculations expected or actual maintenance expenditure is considered against some form of measure of service; although these are defined and benchmarked differently in different areas. As stated, these approaches to understanding the service delivery costs are closely aligned with utility service provision in developed countries; although the expansion in to the IB-NET system does suggest wider penetration of these accounting approaches in to lower and middle-income countries.

However this is proving to be an incremental process in rural water and sanitation sector and there remains confusion between the financial and economic costs of delivery services, especially in how these relate to notions of financial sustainability and cost recovery (Waughray and Moran, 2003).

### 2.2.1 Understanding maintenance costs

Conceptually, maintenance is undertaken to ensure that the system can continue to deliver the output for which it was initially built (Gyamfi et al., 1992).

The WHO (2000) sought to define two types of maintenance based on the size and regularity of expenditure. “Regular maintenance” was defined as “the ongoing activities required to sustain existing assets”. Alternatively “rehabilitation” entails the correction of major defects and the replacement of equipment to enable a facility to function as originally intended. Rehabilitation becomes necessary when it is no longer technically feasible or economically viable to maintain an existing facility in good working order (WHO, 2000).

Franceys and Pezon (2010) make a similar distinction between the ongoing annual operational costs to keep a system running (wages, energy and treatment costs) and the potentially higher "capital maintenance" costs of renewing and rehabilitating failed asset systems. They reasonably contend that the type of technologies that are constructed in lower-income countries, particularly point source systems such as boreholes and handpumps, are only achieving a very short service life and require  costly capital renewal, achieved primarily through 'new projects' rather than lower-cost maintenance. Defining capital maintenance as distinct from minor maintenance and operating expenses is to make it clear to service providers and communities that these costs need to be budgeted for if a level of service is to be sustained.

### 2.2.2 Failure to finance lower-income countries

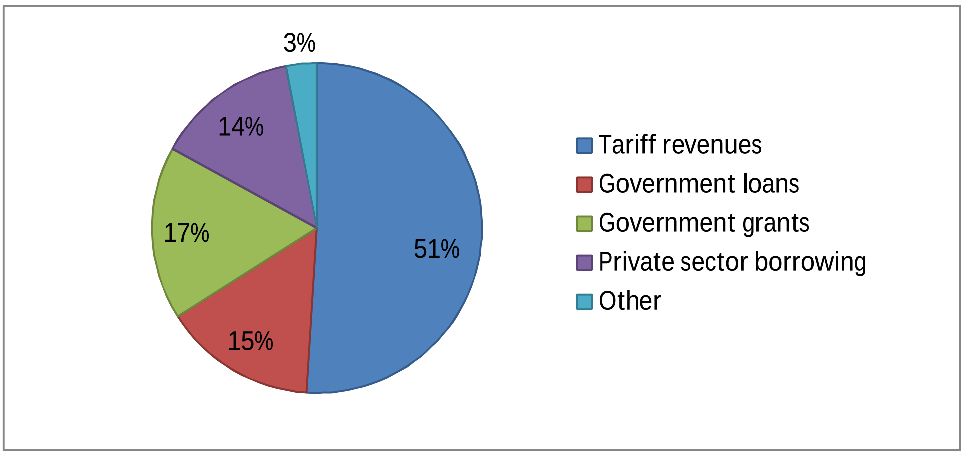
A major challenge of rural water and sanitation provision is mobilising sufficient funds for the ongoing maintenance and renewal of infrastructure assets to prevent the degradation of the physical infrastructure and to maintain a service to users (Sohail et al., 2005; DFID, 2001).

A large-scale and credible study of water and sanitation systems in 16 sub-Saharan countries identified inadequate operation and maintenance as the key cause of premature breakdown of services (UNDP-WSP, 2006). The linkages between the asset failure and inadequate system maintenance have been identified in numerous studies (RWSN, 2010; Skinner, 2009; Haysom, 2006; Baumann, 2006; Mackintosh and Colvin, 2003; Evans, 1992).

In India, Briscoe and Malik (2005) highlight that much of the costly urban and rural water system is rapidly degrading due to insufficient basic maintenance and repairs. They cite a combination of insufficient consumer revenue collection, significant overstaffing, and insufficient budgetary allocations as contributory factors to low levels of maintenance (Briscoe and Malik, 2005). Conversely, Bakalian and Wakeman (2009) in a study of community managed schemes in Peru, Bolivia and Ghana, identified a positive relationship between communities charging volumetric tariff's to cover ongoing costs and service.

The challenge of financing capital maintenance expenditure is not limited to lower-income countries. In an evaluation of rural, small town systems in the USA, Pearson (2007) found that although the majority of supply infrastructure was nearing the end of its useful life, financing arrangements had not been put in place to meet the cost of required rehabilitation and replacement programmes. The study went on to show that user tariffs were funding only 51% of operation and maintenance costs, with the remaining leveraged through government and private sector loans and government grants (Figure 2-1).

**Figure 2-1: Small town utility financing in the USA**




Source: Pearson, 2007

Adank (2013) and Pilgrim et al. (2007), in respect to developing countries, highlight the diseconomies of scale that can affect the financial sustainability of small town water systems. Pearson (2007), also discusses this in respect to the USA. In small towns there tends to be a (relatively) small customer base compared to the amount of infrastructure that is put in place. Consequently the per person costs of constructing, operating, and maintaining a piped water network are greater than more urbanised and populous areas meaning that small towns are often more reliant on external sources of finance (Pearson, 2007).

Theoretically, different asset maintenance strategies have different cost and service level implications. Scarf and Martin (2001) categorise maintenance strategies into three groups, these are: 1) Failure-based maintenance – maintenance of the asset only at the point of failure; 2) Time-based and use based maintenance – scheduled maintenance at specific intervals (either a period of time, or a usage threshold) and upon failure; and 3) Condition based maintenance – maintenance based on the condition of an asset.

Failure based maintenance is a reactive maintenance strategy that may require substantial funds being mobilized on an ad hoc basis to service repairs. On the other hand, time, use and condition based maintenance are preventative maintenance strategies which, necessitate "future orientated" decision-making to prolong the performance or service life of an asset through systematic maintenance to minimize costs and avoid service failure (Cromwell et al., 2001).

Urquhart (2006) notes that different maintenance strategies will be appropriate for different classes of assets - these strategies should not only be based on how an asset fails but also the probability and consequence of this failure. If an individual asset is a crucial component of the asset system that wears out with age, a preventative maintenance strategy may be adopted, which, if well organised, aims to prolong the life-span of the technology, reduce the frequency of repairs and result in lower overall maintenance costs (Brikké and Bredero, 2003).

The decision on whether to maintain or rehabilitate an asset can be a difficult judgement for service providers. Byrne et al., (2003) notes, that if capital maintenance is deferred for too long, it is likely that the eventual costs of rehabilitation will often be higher and the risk to the continuity of service delivery will be greater. Given perfect knowledge, persevering with corrective or preventative maintenance should be recognised as uneconomic when the long-term cost of rehabilitation and subsequent operation will be lower than meeting the increased repair and maintenance costs of deteriorating assets (Davis and Brikké, 2009).

In the lower-income country context, evidence of the potential trade-offs between "maintenance" and "capital maintenance" have come from the road sector. Over the past two decades large scale donor funding has led to massive expansion in road coverage worldwide in developing countries (Rioja, 2003). However post construction many of these networks are falling in to a dis-repair. In an empirical analysis of the financial consequences of inadequate maintenance, Rioja (2003), showed that the costs of repairing a road after three years of neglect is six times the combined maintenance costs, and this rises to eighteen times after five years of neglect.

The analysis went on to show that a re-allocation of donor resources away from new capital investment of roads, and towards the ongoing maintenance of existing networks would have a greater positive impact on overall welfare (measured as GDP).

The process by which infrastructure management aims to collect, analyse and utilise cost data in decision making is known as "asset management planning". The aim of these techniques is for managers to transition from simply having access to cost data to applying cost knowledge to minimize uncertainty in their financial, budgeting and performance forecasting (Trengrove, 2013). Asset management in the water and sanitation sector is a process aimed at "managing infrastructure capital assets to minimise the total cost of owning and operating them, while delivering the service levels customer's desire" (Schulting and Alegre 2007). In simplified terms infrastructure asset management seeks to put a systematic process in place that provides "the right amount of work on the right assets in the right time period for the right price" throughout the life cycle of an asset (Emery, 2005).

### 2.2.3 Operational costs

Linked to ongoing maintenance costs are the continuing management costs. These are commonly understood to include staff, electricity or any treatment materials as they relate to asset system (Jagals and Rietveld, 2011). This understanding is broadened by Ofwat who attribute costs such as "general

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support", and "customer service" into the operation component of total "service costs" (Ofwat, 2005).

In the rural water and sanitation sector the decentralisation of service delivery means that different roles managing, financing, and supporting service delivery are fragmented across a range of actors: households, communities, local government, national government, local NGOs and donors. These actors represent an interconnected network and all have an impact on the how services are delivered. This conceptually is well captured by Carter et al. (1999) who state that community managed water and sanitation systems rely on a "sustainability chain" consisting of four components: the *motivation* of the community members to use the service over alternatives, the *maintenance* of the infrastructure ensuring the availability of spare parts, the *recovery of service costs* from community members, and the *continued support* to communities outside the project intervention cycles. Weakness in any link of this chain is therefore likely to impact on how services are delivered. Consequently efforts are being made to better understand the costs, role, and effectiveness of providing this "support", and these are summarised below.

For many lower-income countries and specifically small communities, the community ownership and management of services remains the dominant model of service provision (Lockwood and Smits, 2011; Harvey and Reed, 2007). However this does not mean that communities necessarily manage their services effectively and it does not mean that the community is actively engaged. Indeed, one of the "myths" of the rural water sector is that after only minimal training, community organisations will be willing and able to manage and maintain the rural water systems (RWSN, 2010).

Since the turn of the century the evident limitations and fragility of the community management approach have come to be seen as reflective of institutional failures to ensure the ongoing technical, financial and managerial support of community bodies (Schouten and Moriarty, 2003). In the literature this has been variously termed as "direct" or "external" support, long term "institutional" support, or "community management plus" (Fonseca et al., 2011; Harvey, 2007; Baumann, 2006). This is premised on the belief that periodic and systematic institutional support in the form of sensitisation and training ("software") will help keep communities motivated, trained, and integrated within wider maintenance and supply chain networks (RWSN, 2010). However beyond agreeing that ongoing support is important, there is little agreement on the type (technical, financial, managerial), means, and regularity of support required (Bakalian and Wakeman, 2009).

Emerging data from lower-income countries suggests that structured external support can improve the performance and sustainability of community services. A comprehensive four country review of WaterAid projects concluded that on-going support is a key factor in increasing the longevity and resilience of community management bodies (Blagbrough, 2001). Prokopy et al (2008) in a multi-village case study in rural Peru found that villages that have access to external technical support are more likely to undertake operational and capital repairs than those that are unable to access support. Similarly, ongoing technical support by trained "circuit-riders" was linked to improved community administrative and maintenance performance in El Salvador (Kayser et al., 2010). In a Ugandan community, managed water systems with external support available enjoyed greater functionality and longevity (Carter and Rwamwanja, 2006). In relation to small towns, a review of community managed piped systems in Ethiopia, Malawi and Kenya found that systems were more vulnerable to management failure when professional and technical support networks are not in place (WSP-AF, 2002; see also Kleemeier, 2000).

### 2.2.4 The "life-cycle" costs of service delivery

As discussed in detail in the previous sections, the capital and recurrent costs associated with delivering water and supply services go beyond the hardware costs of constructing and maintain the system. Furthermore expenditure on costs are inter-related and trade-offs between short-term and long-term expenditure are possible.

These broader service delivery costs are captured by the WASHCost "life-cycle costs" framework for classifying service delivery costs as proposed by Fonseca

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et al., 2011, developed from extensive work with the African Development Bank in developing methodologies for calculating user Charges for non-networked rural water and sanitation (Fonseca et al., 2010). The WASHCost framework and the methodology underpinning it, is adopted in the thesis as the primary means to classify and analyse costs data.

The life-cycle costs of a service are defined as the "aggregate costs required to maintain sustainable services indefinitely", rather than just over the life-cycle of a particular asset system (Fonseca et al., 2011). The WASHCost framework includes not only the direct cost of maintaining infrastructure assets, but also the associated, indirect, costs of supporting service delivery such as those incurred as part of district and national level administration, planning, and policy making (Table 2-3).

**Table 2-3: WASHCost Life-cycle cost components**

| **Cost components** | | **Definition** |
|---|---|---|
| Capital expenditure<br>The costs of providing a service where there was none before; or of substantially increasing the level of services. | Capital Expenditure Hardware | Capital invested in constructing or purchasing fixed assets such as concrete structures, latrines, pumps and pipes to develop or extend a service. |
| | Capital Expenditure Software | The costs of one-off work with stakeholders prior to construction or implementation, extension, enhancement and augmentation (including costs of one-off capacity building). |
| Recurrent expenditure<br>Service maintenance expenditure associated with sustaining an existing service at its intended level | Operational Expenditure | Operating and minor maintenance expenditure; typically regular expenditure such as labour, fuel, chemicals, materials. |
| | Capital Maintenance Expenditure | Asset renewal and replacement cost; occasional and 'lumpy' costs that seek to restore the functionality of a system, such as replacing pump rods or foot valves in hand pumps or a diesel generator in motorised systems. |
| | Cost of Capital | Cost of interest payments on micro-finance and loans used to finance capital expenditure. Cost of any returns to shareholders by small scale private providers. |

| | | |
|---|---|---|
| | Expenditure on Direct Support | Expenditure on support activities for service providers, users or user groups. |
| | Expenditure on Indirect Support | Expenditure on macro-level support, including planning and policy making, support to decentralised service authorities or local government. |

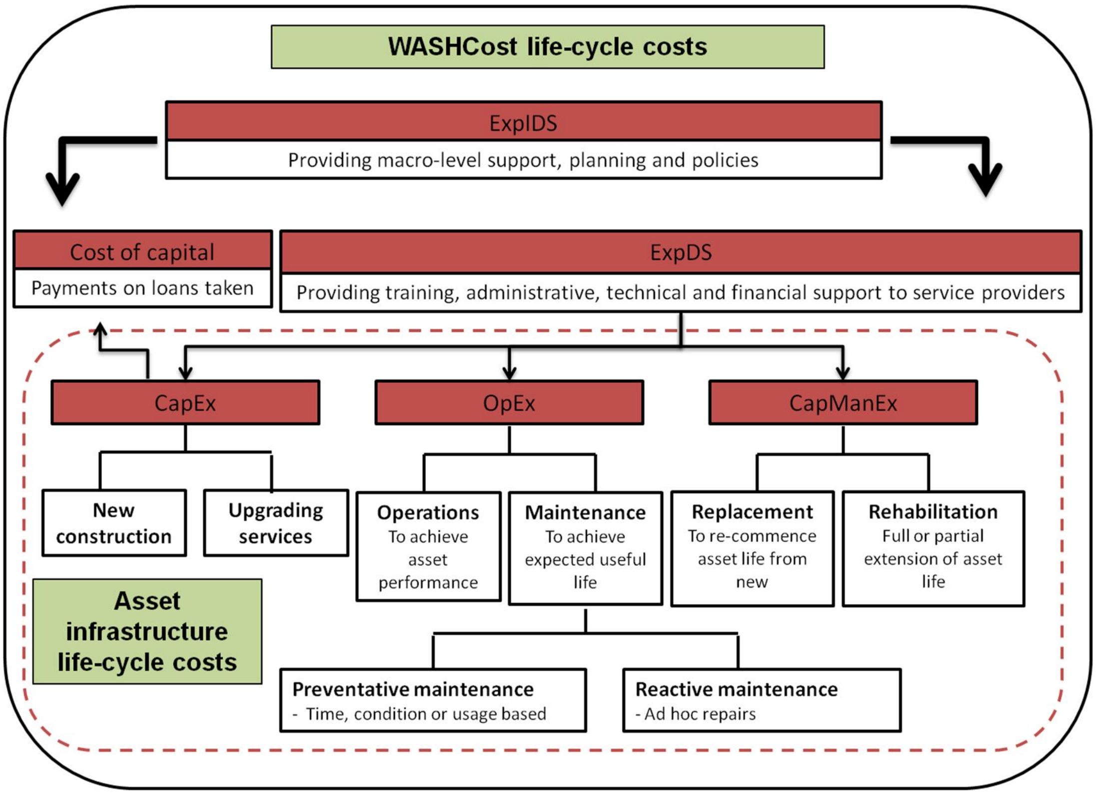
Source: Fonseca et al., 2011

Adapting the regulatory accounting approach – the capital costs (which are considered to be one-time costs) of system construction are separated from the annual recurrent costs of operational expenditure, capital maintenance expenditure and the cost of capital, along with the direct and indirect support costs – that are considered the total aggregated cost of operating the system (Fonseca et al. 2011a).

The conceptual approach of WASHCost, building on the approach of regulatory accounting, is focussed on the maintenance of a service to the user, rather than focussing on solely the infrastructure. This approach is aligned with central tenets of a service delivery approach (SDA), as conceived by de la Harpe (2011) and Lockwood and Smits (2011). Under an SDA, once a water or sanitation system has been constructed the service is maintained indefinitely through a planned process of administration and management, with occasional capital intensive interventions to upgrade the service level (expand and/or enhance) and for replacement.

The relationship between the WASHCost “life-cycle” unit costs of maintaining a “service” and the infrastructure costs of maintaining the components of an asset are shown in Figure 2-2.

**Figure 2-2: Unit costs of providing water and sanitation services**




Source: Author's own creation

In order to understand the relationship between different unit costs and sustainability it is necessary to have benchmarks which define acceptable levels of service. Without an understanding of the level of service being achieved, it is difficult to draw meaningful conclusions about the effectiveness and sufficiency of expenditure. The issue of service levels is the focus of the sub-section 2.4. The next component of this literature review however, turns to an assessment of the state of sector knowledge and the availability of empirical evidence in relation to the capital and recurrent costs of service delivery.

## 2.3 The availability of unit cost data

### 2.3.1 Academic literature

This sub-section examines the available academic literature relating to the costs of either constructing or maintaining water and sanitation systems in lower-income countries.

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A systematic review of available literature was undertaken using a search of key terms within the Scopus bibliographic database. The Scopus database was chosen for its comprehensiveness – covering over 20,000 peer review journals - and furthermore was recommended as the most appropriate resource by the information specialist at Cranfield University library services. The variety of different key search terms were tested to sufficiently narrow the number of results to academic and peer reviewed source, explicitly focussed on the topic area, but without being unnecessarily restrictive. The search terms used as well as the summary of results are shown. Full details of the parameters of the search and the list of results are shown in Appendix B.

**Table 2-4: Scopus journal search parameters and results**

| Study area | Search terms | Results |
|---|---|---|
| Water | Search term (title): *"water supply", cost* | 25 articles found. Two provided empirical data on the financial costs of rural/small water supply systems, 1 provided an estimate of costs. |
| | Search term (title - abstract - keyword): AND *rural* | |
| | Search term (title - abstract - keyword): OR *developing country*, OR *low income* | |
| | Limits: ONLY *article, book chapter, review* | |
| Sanitation | Search term (title): *sanitation, cost* | 22 articles found. Three provided empirical data on the financial costs of sanitation systems. |
| | Search term (title - abstract - keyword): AND *rural* | |
| | Search term (title - abstract - keyword): OR *developing country*, OR *low income* | |
| | Limits: ONLY *article, book chapter, review* | |

In the case of water, four of the twenty five articles returned, reported empirical findings on the cost of different aspects of water supply. However only two of these were related to rural water systems and each of these was over 20 years old and reported solely on capital expenditure values (Schur, 1994; Zoppis and Zoppis, 1989). One more recent study did provide capital cost data for borehole and handpump system but the provenance or calculation method for this data was not reported (Jeuland and Whittington, 2009).

In the case of sanitation only three of the sources provided empirical data on the cost of rural sanitation and one of these was an output of the WASHCost project in India (Van Dijk et al., 2014; Reddy and Batchelor, 2012; and Waterkeyn and Cairncross, 2005).

For both searches the majority of returned articles related to health economics and represented various attempts to evaluate the costs and benefits of the provision, or the absence of provision, of water and sanitation infrastructure in the context of maintaining health (10/25[5] articles for water; 10/22[6] articles for sanitation). None of these studies had based the financial component of the analysis on locally collected financial costs. Either the costs were estimated or were derived from the few non-academic sector sources on water and sanitation costs that in many cases were generated many years previously (these sector sources will be discussed later in the chapter).

This literature search has demonstrated the paucity of academic research into financial costs of delivering services. One likely reason is that in the developing country context, information management at community, local, and national levels is very poor and presents a significant barrier to the collection of financial cost data. These problems can be exacerbated when dealing with sensitive information such as budget and expenditure tracking by private individuals and government (Trémolet and Rama, 2012.

Similarly Estache (2006), found that the complete absence of credible performance and financial data severely limits attempts to assess the performance and cost efficiency of public infrastructure in developing countries, In conclusion this paper found that *"most of the information necessary to ensure a minimal level of accountability from government, donors and operators is either estimated very roughly, very occasionally or often is never collected."* Indeed the current absence of systematic and transparent data on service delivery costs is one of the primary drivers of this research study.

The following section provides a critical overview of the current state of knowledge and understanding of the financial costs of delivering services for all available data sources. These include sector reports, "grey literature", the

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[5] Fahimuddin, 2012; Hunter et al., 2009; Jeuland and Whittington, 2009; Macrae and Whittington, 2009; Hutton and Bartram, 2008; Hutton et al., 2007; Ilahi and Grimard, 2000; Tang et al., 1996; Watts, 1992; Pinfold, 1990

[6] Gunther and Fink, 2013; Bartram et al., 2012; Govender et al., 2011a; Govender et al., 2011b; Hutton and Bartram, 2008; Hutton et al., 2007; Haller et al., 2007; Varley et al., 1998; Pinfold, 1990, Cvjetanovic and Grab, 1976

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academic sources identified, as well as others encountered in wider reading but not found in the database search. Relevant cost data is extracted from these sources. For comparisons between these values, where indicated historical cost data has been brought to a common base year of 2012 using World Bank GDP deflators (these calculations have been made according to methodology described in section 3.7.3).

## 2.3.2 Grey literature

### 2.3.2.1 Capital costs

At the global level, Christmas and Rooy (1991) provide one of the earliest estimation of the global per person capital costs for water and sanitation – technologies are not specified but an estimate is given for rural, peri-urban and urban areas (Table 2-5). The capital costs of rural water supply are estimated at around one third of peri-urban costs and one seventh of urban costs (2012 $51 - $341). The estimated capital cost of sanitation is given to be between 2012 $ 34 – $ 43 in rural and peri-urban areas, but is almost 20 times greater in urban areas where high cost sewerage networks would be expected.

**Table 2-5: Estimates of water and sanitation capital costs**

| Type of supply | Capital cost per person ($ 1991) | Capital cost per person ($ 2012) |
|---|---|---|
| **Water** | | |
| Rural | $30 | $51 |
| Peri-urban | $100 | $170 |
| Urban | $200 | $341 |
| **Sanitation** | | |
| Rural | $20 | $34 |
| Peri-urban | $25 | $43 |
| Urban | $350 | $597 |

Adapted from: Christmas and Rooy, 1991

The next global study of global capital costs was the Joint Monitoring Program Global Water and Sanitation and Assessment Report (WHO/UNICEF, 2000). This report derived infrastructure costs from data compiled by UNICEF programme staff in Africa, Asia and Latin America and the Caribbean, in order to

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estimate the costs of reaching the Millennium Development Goals. The capital expenditure figures for different water and sanitation asset systems were then averaged to generate a unit cost per person for water systems and a cost per system for sanitation facilities (Table 2-6). In compiling this information the report authors recognised that data availability, and system design, varied greatly between different countries and it was often unclear if all capital costs were captured.

**Table 2-6: Capital Cost of water and sanitation technologies**

| Region | Capital cost per system ($ 2000) | Capital cost per person ($ 2000) | Capital cost per system ($ 2012) |
|---|---|---|---|
| Stand post | | | |
| Africa | - | $31 | $41 |
| Asia | - | $64 | $84 |
| Latin America and Caribbean | - | $41 | $54 |
| Borehole and Handpump | | | |
| Africa | - | $23 | $30 |
| Asia | - | $17 | $22 |
| Latin America and Caribbean | - | $55 | $72 |
| Traditional pit latrine | | | |
| Africa | $39 | - | $51 |
| Asia | $26 | - | $34 |
| Latin America and Caribbean | $60 | - | $79 |
| VIP Latrine | | | |
| Africa | $52 | - | $68 |
| Asia | $50 | - | $66 |
| Latin America and Caribbean | $57 | - | $75 |
| Pour flush latrine | | | |
| Africa | $60 | - | $79 |
| Asia | $50 | - | $66 |
| Latin America and Caribbean | $91 | - | $119 |

Source: WHO/UNICEF, 2000

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Despite these limitations the WHO/UNICEF report has been widely used as the baseline data for subsequent research into costs/benefit analyses for water and sanitation investments (Hutton and Haller, 2004; Hutton et al., 2007). The general nature of these figures as well as queries about how they have been compiled (UNEP, 2004), mean they can only be taken as broadly "indicative" of true capital costs (Hutton and Bartram, 2008).

Other studies have suggested a variety of capital cost ranges for WATSAN infrastructure across different countries (Africon, 2008; OECD, 2005; Robinson, 2009). Each of these studies has noted the difficulty in extracting comparable data sets that could be utilised in a robust cost analysis. The Africa Infrastructure Country Diagnostic (2007) identified that the costs of infrastructure services on Africa varied greatly within and between countries according to the rural-ness of location and population density.

Recently, Fonseca (2014) compiled a data set of detailed capital expenditure ranges for different water and sanitation technologies from a variety of grey literature sources from the years 2001 – 2010. The review bought together cost information relating to Africa, Asia and Latin America (Table 2-7).

**Table 2-7: Overview of grey literature relating to capital expenditure for rural water and sanitation systems**

| System type | Mean/ US$ (2012) | Range US$ (2012) |
|---|---|---|
| *Water* | | |
| Hand dug well | $30 | $5-$95 |
| Borehole and handpump | $43 | $3-$109 |
| Small town piped system | $92 | $50-$139 |
| Medium piped system | $146 | $32-$286 |
| *Sanitation* | | |
| Traditional pit latrine | $28 | $1-$120 |
| Ventilated improved pit latrine | $52 | $6-$113 |
| Pour flush latrine | $74 | $4-$181 |
| Toilet with septic tank | $154 | $27-$318 |

Source: Adapted from Fonseca (2014)

In compiling this review, Fonseca (2014) emphasised that there were large regional variation between countries, but also noted that sanitation options were more expensive in Africa and Latin America as compared to Asia. Particular concerns were raised about cost data from India and South Africa which were based on an official bill of quantities data, giving the maximum cost ceiling, rather than expenditures. However the difference between cost estimates and actual expenditures was rarely made explicit.

The large range in latrines costs is indicative of variations in the robustness of materials used for construction of at least nominally equivalent latrine "technologies" in different country contexts. This difference is effectively shown through the comparison two studies of latrine construction costs in East Africa (O'Loughlin et al., 2006; Van Dick et al., 2014). In both cases the main latrine being sampled was defined as an "unimproved[7] pit latrine", but whereas O'Loughlin et al., (2006) found that over two thirds of households in rural Ethiopia had spent nothing on constructing their latrine, and even those that incurred a cost spent $4.0 just per latrine; Van Dijk et al., (2014) found that construction costs for the same latrine technology in urban slums of Tanzania and Uganda ranged between $222 and $318.

With respect to rural water supply, the cost of borehole drilling is one subject that has been relatively well researched in the sector. A variety of studies have focused on the drivers of drilling costs to inform more cost effective planning and investment in rural boreholes (Danert et al., 2008; Ball, 2004; Smith, 2003).

Examining data from various country contexts, Carter et al (2006) identify 10 factors to reduce the costs of borehole drilling. These focus on improving the management, packaging and implementation of borehole drilling by ensuring that a) increased knowledge of ground water resources and flows is accessed; b) smaller drilling rigs are used where appropriate and c) that borehole contracts are packaged according to site location and geology to reduce travel and drilling

[7] An "unimproved" latrine is the terminology used in the sector to denote a latrine that does not provide adequate safe separation between the user and the pit. This is the classification utilised by the joint monitoring programme of the Millennium Development Goals and is explored in more detail in section 2.4.

times. The available data on borehole construction costs were systematized into a predictive costing model by Heath (2009). The model examined a few key borehole characteristics, such as depth, geology, fuel prices, and type of drilling equipment to generate a series of unit costs at different phases of the drilling process: mobilization, drilling and well development. Iterations of this model highlighted considerable variations in borehole drilling costs both within a single country and between different countries.

Jeuland and Whittington (2009) note that across Africa, the influx of competition from Chinese drilling rigs in recent years has led to a dramatic fall in borehole drilling and handpump installation costs – some as much as 50% from approximately $12,000 to approximately $6,000.

As recognised by DFID (2012) “further work is required to develop more accurate estimates of unit costs in the WASH sector and to understand the major drivers in costs across sectors”.

**2.3.2.2 Recurrent costs**

As emphasized in studies by Pezon (2010) and Van Ginneken et al. (2011), within national contexts, even a basic understanding of the recurrent costs of service delivery are missing and therefore most budget and planning decisions are made solely on future capital expenditures.

A study by Fonseca and Cardone (2006) serves to emphasise this point. In a critique of three costing studies, relating to 12 sub-Saharan countries, it was shown that global studies ignored many of the crucial costs of service provision, namely: the costs of major repair and replacement as well as the costs of providing on-going support to community bodies. They argue that the costs of capital maintenance are not factored into decision making and consequently, when expenditure is required, no agency – whether local or national government, donors or communities – has planned for these. The report concludes that donors and other sector stakeholders should work towards having better documentation of maintenance and support costs – to create country level values that can be used for investment planning and budgeting.

Building upon this theme, in an analysis of grey literature after 2001, Fonseca (2014) was able to collate a sample of data on the maintenance costs of different water and sanitation technologies (Table 2-8), although this was considerably less than what was available for capital costs. The cost range for point-source community water systems was found to be between $0 and $1 per person per year (mean $0.3), about a third of small piped systems (mean $0.9), and considerably less than medium piped system ($12.2). Interestingly the per person, per year maintenance costs of latrines was greater than most water systems. Data on actual and required capital maintenance was identified as the largest gap in the literature, with only occasional data available. More generally the comparability of data was hindered by the varied use of terminologies between different studies (Fonseca, 2014).

**Table 2-8: Overview of grey literature relating to recurrent expenditure (OpEx and CapManEx) per person per year on rural water and sanitation systems**

| System type | Mean/ US$ (2012) | Range US$ (2012) |
|---|---|---|
| *Water* | | |
| Hand dug well | $0.3 | $ 0-$1 |
| Borehole and handpump | $0.4 | $ 0-$1 |
| Small town piped system | $0.9 | $ 1-$1 |
| Medium piped system | $12.2 | $ 3-$18 |
| *Sanitation* | | |
| Traditional pit latrine | NA | NA |
| Ventilated improved pit latrine | $13 | $ 6-$19 |
| Pour flush latrine | $5 | $ 1-$7 |
| Toilet with septic tank | $36 | $ 19-$52 |

Source: Fonseca (2014)

The literature suggests that operating costs have typically been taken as an estimate of capital expenditure, varying between 2 and 15 percent, without reference to the actual maintenance requirements of different systems (Hutton and Bartram, 2008; Whittington et al., 2009). Where cost data does exist for OpEx is mostly limited to borehole and hand pump schemes. Quoted annual maintenance cost figures range between $35 (Harvey and Reed, 2004), $60 (Osafo-Yeboah, 1994) and $100 (Whittington et al., 2009) per system, per year.

These studies identify that values do vary considerably from unit to unit with the drivers of this variation unexplored.

Beyond the grey literature there are few empirical studies of operating costs of other non-networked water and sanitation systems. It is expected however that annual maintenance requirements of more advanced systems (not including complex utility networked operations) will be greater than simpler technologies due to the higher levels and technical expertise needed to repair these systems (Robinson 2009; WSP 2011; Brikké and Rojas 2001). However, the way in which greater expenditure on piped systems relates to the cost per person served, as well as to the quality of services delivered, has not been adequately explored in the literature. In the absence of sufficient data, calculating the operating and maintenance costs as a percentage of capital costs is recognised as a necessary simplification (Jagals and Rietveld, 2011).

For "on-site" sanitation systems the major maintenance requirement after construction usually relates to the need to periodically empty the pit when it has become full; or in the case of the most rudimentary latrines seal the old pit and re-site the latrine in a new location. In rural areas these costs are not quantified, however in urban areas a number of studies have reported on these costs. For mechanical pit emptying Chowdry and Kone (2012), found a wide variation in costs between Asian and African cities ($48 - $134 respectively), whereas Van Dijk (2014) identified mechanical pit emptying costs at between $44 and $70, that could be incurred as often as every six months is the latrine is consistently used.

Evidence in the sector of the poor performance and high rates of failure of asset systems suggest that CapManEx is woefully underfunded in rural and small town areas in lower-income countries. Furthermore inadequate ongoing operations and maintenance is likely to mean that manufacture guidelines on asset design life spans will not be met (Ashworth 1996).

In a review of government financial planning processes in four developing countries, Pezon (2010) found that capital maintenance activities are not acknowledged or accounted for in budgeting and planning policies and processes. A later study by Le Gouais and Wach (2013) evaluated the policy documentation of eleven development partners (covering multi-lateral donors, bi-lateral donors, NGOs) and similarly found that although the need to finance operation and maintenance costs was acknowledged by partners, only three (3) recognised the need to account for eventual capital renewal and replacement.

More accurate assessments of the level of expenditure required for CapManEx requires more detailed information on the asset base in a particular service area, ideally through an inventory of the age, condition and expected lifespan of key assets, allied with an appreciation of their likely replacement costs (Fonseca et al., 2011). The absence of CapManEx data reflects how sector actors have failed to acknowledge that at some point in the future all fixed assets will need to be significantly repaired or replaced if services are to be sustainable.

A small number of studies have begun to explore the cost of providing “direct support” to communities to help ensure improved local management. A short study by Baumann (2006) argues that greater annual expenditure on borehole maintenance in the near term will reduce the long term costs for rural communities. This study works on the assumption that the moving from a basic level of operating expenditure under a traditional community management system ($25 per borehole per year) to an ideal level of operating expenditure under “community management plus” ($235 per borehole per year, including the staff costs of district mechanics who would maintain the infrastructure), would extend the functional lifespan of the hand pump from 5 to 10 years (Figure 2-3).

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**Figure 2-3: Community management and community management "plus"**

**Community Management**

-Minor operation and maintenance is financed by community members
-There is no technical or institutional support or oversight
- Repairs which are beyond the (financial or technical) capacity of the community to finance are not done
- Service fails

-----------------------------------------

**Cost: Approximately US$25 per year**

**Community Management Plus**

-Minor operation and maintenance and part of more major repairs financed by community members
-Local government provides back up and institutional support
- Extra financial and technical support means the service is sustained

-----------------------------------------

**Cost: Approximately US$ 235 per year – divided between 28% users, 60% local government, 12% central government**

Source: Adapted from Baumann 2006

Other studies have conceptualised direct support costs as a cost per person rather than a cost per system. Jones (2013) put the cost of providing support by WaterAid's programme in Mali at $0.5-1.5 person/year, somewhat higher that the Government of Mali's programme of $0.34 person/year. In study of Water for People's approach in Bolivia, Fogelburg (2013) reports an average direct support cost at $0.15 per person per year.

Gibson (2010) examined the costs of providing technical support to rural water systems in South Africa. In this model the operational, technical, and administrative responsibility was delegated to a private sector "service support agent" that would in turn liaise with community based organisations.

This study found that that the costs of providing technical support and backstopping to the community represented a high proportion of the annual recurrent costs of the system, and significantly more than expenditure associated with materials, fuel and spares. The total expenditure in operational costs and support in two districts ranged from $16 - $42 per person per year, well in excess of percentage based estimates of construction costs.

Across the literature there is no data available on the costs of indirect support, i.e. those associated with developing a legal and policy framework for rural water and sanitation services. Similarly information on the costs of capital are hard to generalize as these will be specific to amount borrowed, the agreed payback period and the type of agent borrowing the money. Franceys et al. (2011) suggest that over a loan period of 50 years, a government may be given a soft loan by a development back. The interest of the loan is likely to range from 0.5% to 0.75%; the repayment of principal would begin after 10 years at 1% per year and then 3% per year for the remaining period. The interest rates for capital borrowed by community agencies or households are likely to be much higher, with shorter payback periods. This can place a significant potential financial burden on these actors.

This sub-section has demonstrated that the majority of current research is focussed on understanding the capital costs of delivery of first-time services to new areas. Within the sector, much of the existing research on capital costs has been focussed on the costs of borehole drilling with little context specific evidence of the costs of piped water systems or on-site sanitation systems. Detailed evidence of the necessary recurrent costs of maintaining assets, and supporting service delivery are not systematically available or understood.

The main points to be taken from sections 2.2 and 2.3, are that in the rural areas of lower-income countries, there is only partial knowledge of what it costs to construct water and sanitation systems and virtually nothing is known about the necessary levels of expenditure required to sustain these systems. This is in part due to the absence in the literature of a systematic methodology to define and classify these costs in rural areas and also because the majority of data available are not compared with any measure of the quality, adequacy or sustainability of services being delivered.

This literature review now turns to the appraisal of the academic and sector literature examining the key indicators which make up a “globally acceptable” water and sanitation service.

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## 2.4 Understanding water and sanitation services and costs

### 2.4.1 Defining services

Across the developing world, national policies have laid down benchmark criteria that define acceptable or unacceptable water and sanitation services and these tend to be based on set of indicators broadly aligned with health and economic benefits. These elements of services have been explored in detail in the literature.

The most common indicators of a water service are: quantity measured in litres per capita per day (LPCD); quality, benchmarked against national or international chemical, biological and physical standards; distance and crowding of the water source – either measured in terms of time per round trip or in meters and users of the water source; and, reliability, typically defined using some measure of functionality over time (Moriarty et al., 2011). These indicators have a strong scientific basis. In terms of access to infrastructure, in rural areas it is common for women and children to spend an hour per trip collecting water, often multiple times per day (Montgomery and Elimelech, 2007). As this collection time increases, the quantity of water consumption tends to decrease, the risk of water contamination increases (Trevett et al., 2005; Wright et al., 2004), as do the economic costs of time lost (Hutton et al., *2007).*

Reliability of supply is also important because if there are extended periods of breakdown, users are more likely to revert back to alternative and often unimproved sources, with questionable water quality (Hunter et al., 2009; Pattanayak, et al., 2005) and are therefore exposed to the associated risks of diarrheal and other water borne diseases (WHO, 1997).

Inadequate access to sufficient quantities of water for drinking can have a serious impact on health and livelihoods, conversely population groups that have greater access to water have consistently better health outcomes. There is no single agreed guideline of a basic water quantity, and basic requirements will vary with context. The humanitarian charter on minimum standards (SPHERE) recommend a minimum of 7.5 LCPD for survival levels required for drinking, food, and hygiene. However above this bare minimum amount, a basic quantity is suggested at 20 LPCD for domestic uses (Gumbe et al., 2011; Reed, 2010; Carter et al., 1999) – although some suggestions are as high as 50 LPCD (Gleick, 1996).

The critical elements of a sanitation service delivery can also be broken down into a number of key indicators. Von Münch (2008) contends that an acceptable sanitation service means not only having access to a latrine, but that other facets of the service, such as faecal storage, collection, treatment and re-use, should be safe - that is, not posing threats to the environmental or human health. Once the latrine has been constructed, continued latrine use is important for health outcomes to be maintained (Montgomery et al., 2010) although the challenges of maintaining community behaviour change over time have been well documented in India (CMS, 2011). A study of the "sanitary condition" of latrines in rural Kenya found that only 32% presented a "good" sanitation condition based on cleanliness, smell, and invasion of insects, this lack of maintenance would contribute to increased health risk (GRECDH – UPC, 2011). Due to these complexity of factors Kvarnström et al. (2011) argue for a "function orientated" measurement of sanitation based on the health and environmental benefits they deliver over time.

### 2.4.2 Measuring services

At the global level, a single indicator of water and sanitation services is used to compare progress of different regions and countries towards Millennium Development Goal (MDGs) target 7.C - to "halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation". This indicator monitors an individual's access to either "improved" or "unimproved" water and sanitation infrastructure. Improved water sources include: protected wells, borehole or piped water to a public tab/household. Unimproved water sources include: unprotected ground and surface water sources such as springs or dug wells, tankered or bottled water (WHO/UNICEF, 2008). Improved sanitation is defined as a household latrine that "hygienically separates human excreta from human contact" (WHO/UNICEF, 2012a).

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The MDG targets are influential drivers of investment in the sector and have helped over 2 billion people gain access to improved drinking water sources between 1990 and 2010 (WHO/UNICEF, 2012a), and will deliver an estimated 10% increase in sanitation coverage by 2015 (WHO/UNICEF, 2010). However the binary classification of “improved” versus “unimproved” appears to have focussed attention on putting infrastructure in place rather than ensuring that the system is delivering (and continues to deliver) safe or effective services. This process of infrastructure “box ticking” (Schouten and Moriarty 2005), largely ignores important indicators: such as water quality and quantity, reliability and convenience, that give a much clearer picture of the standard and resilience of the services received by users (Kvarnström et al., 2011). This is effectively illustrated by Onda et al. (2012) in a five country study of rapid-drinking water quality assessments; many improved water sources can provide water that fails to reach accepted micro-biological water quality guidelines, combined with a “sanitary risk” to water from intermittent supply and proximity to latrines means that a generalised estimate of 28% of people may still be accessing unsafe, and therefore unimproved water (Onda et al., 2012). This is almost three times the current Joint Monitoring Programme estimate of 11% (WHO/UNICEF, 2012a).

The failure to meet acceptable service delivery indicators over time, demonstrates the weakness in the global monitoring of the MDGs which incorrectly conflates having access to infrastructure with having access to “safe” water or sanitation services.

High level meeting and discussions in anticipation of 2015 deadline of the MDGs are examining ways sector monitoring can change in post-2015 environment to change from metrics sole focussed on infrastructure provision, or coverage, towards metrics that asses the delivery sustainability of water and sanitation services (WHO/UNICEF 2012; WHO 2012).

### 2.4.3 Services as a ladder

The WASHCost project methodology places a great deal of emphasis on achieving a detailed understanding of water and sanitation services that users receive as a necessary step to being able to better understand the costs of

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delivering these services. Specifically the project was keen to move beyond simple improved/unimproved reporting of the JMP which was seen a poor judge of the quality of services being delivered (Fonseca et al., 2011).

As a result WASHCost developed the water and sanitation service ladders, which outline a hierarchy of service levels ranging from a “no service” level to a “high” service level for water, and from “no service” to an “improved” service level for sanitation (Moriarty et al., 2011; Potter et al., 2011). According to the ladders proposed by WASHCost, a “basic” level of water service is assumed to be achieved when all the following criteria have been realised by a majority of the population in the service area:

- people access a minimum of 20 litres per person per day;
- water is of acceptable quality (judged by user perception and country standards);
- water is drawn from an improved source, which functions at least 350 days a year without serious breakdowns; and
- People spend no more than 30 minutes per day per round trip (including waiting time) to access water.

For sanitation a “basic” level of service is judged according to the:

- accessibility of the sanitation facilities to the household;
- use of sanitation facilities by members of the household;
- cleanliness, maintenance and pit emptying of the facilities; and
- Environmental safety of faecal waste.

If any one of these indicators does not reach this “basic” standard, the overall service is considered to be at the level of the worst performing indicator (Moriarty et al., 2011; Potter et al., 2011). These service ladders and their use in this research are discussed further in 3.7.1.

The development of the water ladder is a progression on previous work undertaken by Howard and Bartram (2003) and van Koppen et al. (2009), which also incorporated multiple indicators of a service into a single framework made up of several levels, or rungs, of service. The sanitation ladder builds upon the conceptual framework of sanitation services forwarded by Kvarnström et al (2011) that focuses on the functions and impacts of the sanitation system, rather than a particular technology.

However, it also must be recognised that the development of multi-indicator frameworks presents additional complexities for data collection and analysis – specifically in resource constrained environments. Critiques of the service ladder frameworks are not well documented in the literature, although some potential challenges of the water services indicators have been identified by Kayser et al. (2013), and some of these can be generalised to the sanitation service ladder.

Kayser et al., (2013) argues that the advantage of the MDG dichotomous improved/unimproved classification is the relative ease in which this data can be collected from diverse and complex geographical settings - allowing comparisons to be made across space and time. In collecting multiple indicators, and also indicators that require direct assessment of assets and extensive household engagement, the service ladder framework is likely to encounter both additional challenges and additional costs in collecting comparable data. Furthermore, by primarily reporting on the worst performing indicator, rather than each individual indicator, the service ladders framework may mask other service benefits that are being delivered. Linked to this, the ladder framework gives equal weighting to each indicator, implying equal impact on overall service delivery benefits, this a big assumption and not grounded in the literature (Kayser et al., 2013). At present these potential weaknesses have not been adequately addressed within the service ladder literature and require testing.

This section has thus far provided an overview of the indicators used to measure water and sanitation service delivery. It now turns to an examination of required cost to deliver and maintain these services. It explores how service delivery costs are defined and the extent to which evidence data has been collected on these costs. This involves reviewing both academic and grey literature at national and international level for evidence of unit cost data related to both maintaining assets and services, and thus allows an identification of gaps in current knowledge.

## 2.5 Theoretical considerations

Understanding the relationship between investments, services, and overall societal well-being is grounded within economic theory, specifically "welfare economics". The discipline of "welfare economics" is concerned with how societies can best use their scarce resources (capital, labour, goods, and services) to maximise social welfare and seeks to provide an empirical basis for assessing how policy makers allocate these resources (Besley, 2004). Within the provision of public services, decision makers at all levels are faced with the challenge of how to maximize the "output" achieved with available resources ("inputs") – in effect trying to make the optimum use of available resources (Vaa, 1993). Welfare economists term this "pareto-efficiency" (also known as "allocative" efficiency) – whereby a decision maker cannot re-allocate resources in a way to increase overall social without causing a decrease in the welfare of others (Palmer and Torgerson, 1999).

The concept of allocative efficiency tends to be applied to the whole economy and seeks to make judgements on how the economic policies and markets should be organised at national level. The scope of this thesis is much narrower, examining the efficiency of investments solely in relation to rural water and sanitation. Therefore the two additional welfare economic concepts of "technical" and "productive" efficiency" become more relevant.

"Technical" (in)efficiency is concerned with the relationship between specific resource "inputs" and social welfare "outputs" for a given system (Worthington, 2011). "Productive" (in)efficiency refers the ratio between the inputs and outputs across a range of different approaches (Palmer and Torgerson, 1999).

The WASHCost methodology applied in this study examines resource "inputs" of any water and sanitation system from a financial rather than an economic perspective. Therefore all resource inputs are captured as a cost within the "life-cycle costs" framework. Social-welfare "outputs" are captured within the WASHCost service level framework, the indicators of which are designed to reflect the most important characteristics of a safe and effective service (Moriarty et al., 2011; Potter et al., 2011). Therefore the conceptual approach of this thesis treats any improvement in the WASHCost service level as reflective of an improvement in social-welfare.

Against this backdrop, “technical efficiency” is achieved by minimising “life-cycle cost” inputs, and maximising the “service level” outputs of a given water or sanitation system. Productive efficiency on the other hand is concerned with comparing the efficiencies of different technology options to then be able to inform and justify the selection of one technology choice over another.

As outlined in the introduction, existing high rates of premature system failure in lower-income countries means that the many of the societal benefits of the services are being lost at a very high financial cost, undermining the efficiency of these investments. The notion of “functional sustainability” emphasises the continued delivery of service benefits in the long term. The overview of the different elements of a sustainable water or sanitation service (fully explained in its historical context in Appendix A) has shown that achieving service sustainability is a complex problem that cannot be reduced to any single determining factor. Nevertheless, the failure of stakeholders to effectively mobilise funds for long term costs of system operation, maintenance, management, and renewal has been identified as fundamental to this failure.

In the developed world the process of infrastructure asset management is a means to guide investment decision making, by seeking to minimize the total cost of owning and operating infrastructure capital assets, while agreed standards of service delivery are maintained – in effect instrumentalising the concepts of technical and productive efficiency.

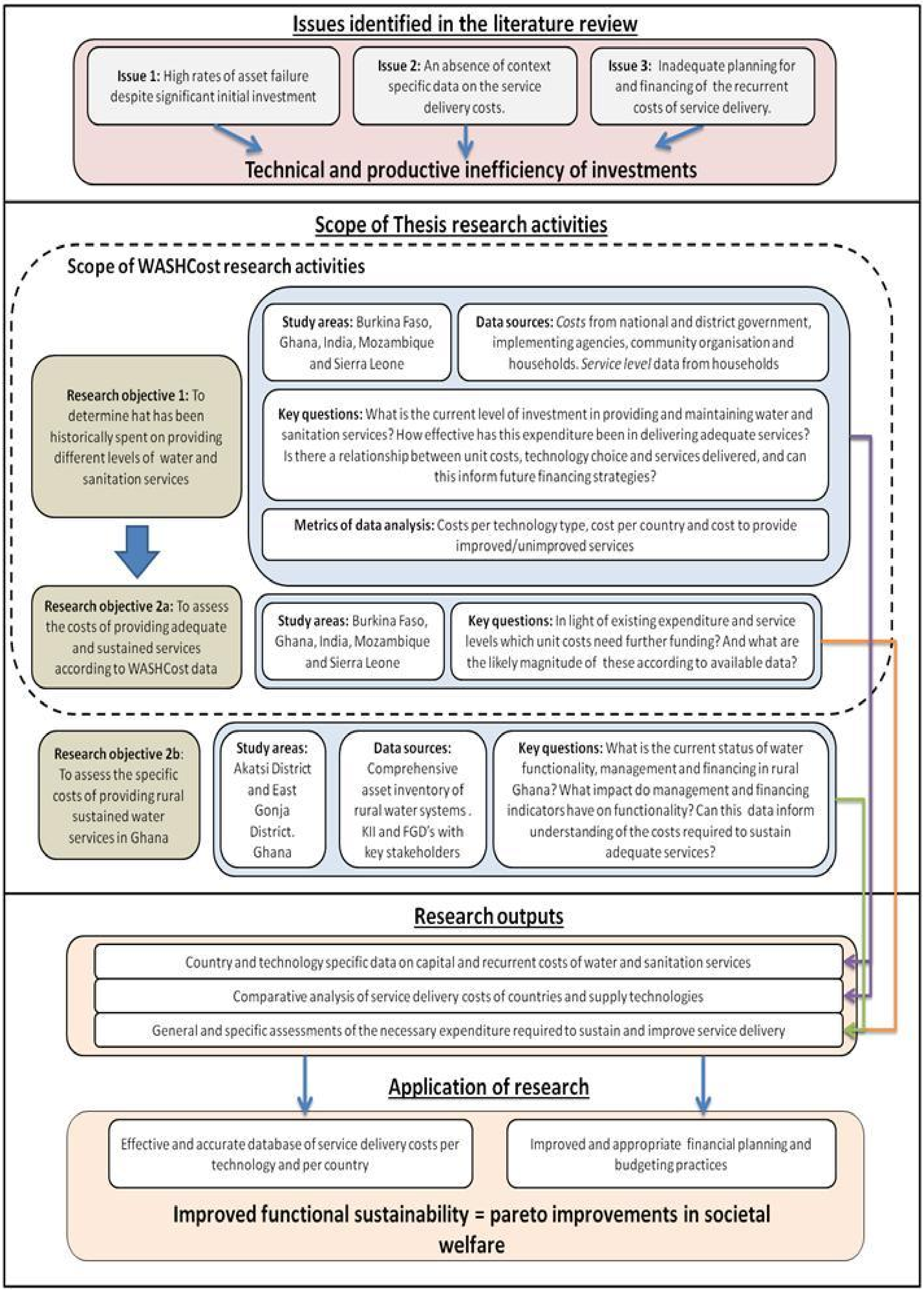
Even a  basic financial plan accounting for the capital and recurrent costs of rural water and sanitation systems, requires a much more nuanced, context specific and evidence based understanding of the relationship between costs inputs (“CapEx”, “OpEx”, “CapManEx” and “ExpDS”) and  service level outputs

The thesis seeks to address these knowledge gaps and in turn help to inform the broader conceptual question of whether improved access to cost data in lower-income contexts can contribute to the improved technical of productive efficiency of water and sanitation service delivery.

## 2.6 Conceptual framework

Miles and Huberman (1984) define a conceptual framework as the “researcher’s map of the territory being investigated” that not only helps the researcher and reader understand the structure of the research (Weaver-Hart, 1988), but also helps make the explicit connections between theory, earlier findings (the literature review), and the purpose of the research (Leshem and Trafford, 2007). The conceptual framework for this thesis which detailing these connections, are shown in Figure 2-4

**Figure 2-4: Conceptual framework**



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# 3 Methodology

This chapter describes the methodology guiding the different phases of the research study as well as the collaborative partnership between the researcher and the WASHCost project. The research was funded by the WASHCost project hosted by the IRC: International Water and Sanitation Centre (herewith referred to as the IRC) based in The Hague. The academic lead was provided by Cranfield University, who were also international advisors to the WASHCost project. For 18 months of the Doctoral research the researcher was based at the offices of IRC as the co-ordinator of research outputs within the “global team” of the WASHCost project, whilst also making regular visits to “country teams” based in Andhra Pradesh state (India), Burkina Faso, Ghana, and Mozambique. As the scope of the project was refined and data gaps identified, additional focused research was undertaken in Ghana, and Sierra Leone.

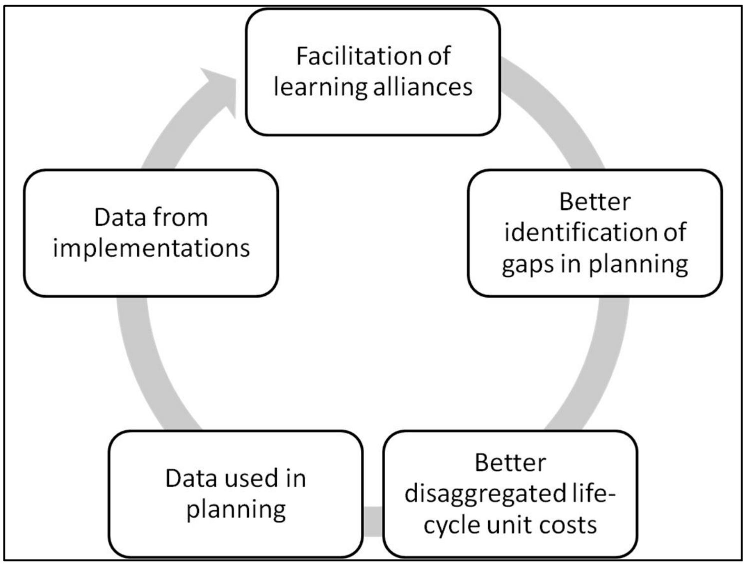
Initially this chapter defines the scope, methodological approach, and “theory of change” of the WASHCost project and examines the positioning of this thesis in relation to the broader research aims of the project. This chapter then turns to the overall scheduling, structure, and purpose of each component of the research process from early 2011 to the end of 2013. It outlines and justifies the different methodologies and analytical approaches used to meet the objectives and sub-objectives of the research as defined in section 1.7. The chapter concludes with a critical reflection on the data collection and analysis process.

## 3.1 WASHCost Project

WASHCost aimed to establish country-specific and disaggregated unit costs of providing water and sanitation services. This entailed both a backward looking analysis – examining the historical costs of delivering existing levels of service – and a forward looking analysis – examining what should be spent to achieve improved service levels. Overall the project hoped to provide an assessment of how this data could be used to improve WASH governance in general, alongside specific evidence of improvements in cost-efficiency, transparency, and sustainability.

Central to the WASHCost approach was ensuring country level research activities were led by a local research team who in turn worked closely with national level “learning alliances” made up of key sector stakeholders. In this respect WASHCost was designed as a classic action-research project that aimed to achieve research-driven change of policies and practices by giving those policy makers and practitioners both a stake and a voice in the research process (Moriarty et al., 2010). These principals are fundamental to the “theory of change” of the entire project (see Figure 3-1). The WASHCost project was split into three principal phases (Figure 3-2). The initial “inception” phase to ensure the ownership of the project amongst country teams; the “research” phase where methodologies were tested and data was collected, analysed and validated; and finally the “embedding” phase where, using the learning alliance model, the new findings on unit costs are integrated into WASH sector decision making (Moriarty et al., 2010).

**Figure 3-1: WASHCost theory of change**




Source: Moriarty et al., 2010

### 3.1.1 Relationship between the thesis and the WASHCost project

The aims and objectives of the WASHCost country led research and this PhD research are intrinsically linked, although the scope and scale of research outputs are different. Whereas the focus of the country research teams was on country-specific findings matched to meet the demands of the country learning alliances, this doctoral research sought a broader comparative analysis between the four country data sets (with the subsequent addition of a fifth country – Sierra Leone), examining the variability of costs and services between country contexts.

As the key research focal person within the “global” team, there was considerable interaction between the researcher and each “country” team, both individually through online meetings and country visits, and also all together as part of global research meetings. The purpose of these interactions was to help ensure common methodologies of data collection and analysis were being followed; to help resolve any analytical or conceptual challenges in the country analysis; and more latterly to ensure the validity of country databases in preparation for comparative analysis (explained in detail in section 3.5.2).

Since joining in 2011 the researcher gained increasing authority within the project to help shape national and international research outputs. This also led to increasing ownership of the direction and scope of the doctoral research, resulting in the expansion of the scope of the research and the application of the methodology to new study areas.

This change process is not uncommon to collaborative research projects as outlined by Macmillan and Scott (2003). They state that in the early stages of collaborative research when a researcher joins a project, there will inevitably be a period when the influence of the partner organisation can dominate and where the researcher looks for guidance from established members of the team who are more familiar with the project design and research setting. However over time the researcher claims ownership over the research process and is able to express autonomy over the direction, analysis and write-up of research outputs, and is also able to influence the work of others within the team (Macmillan and Scott, 2003).

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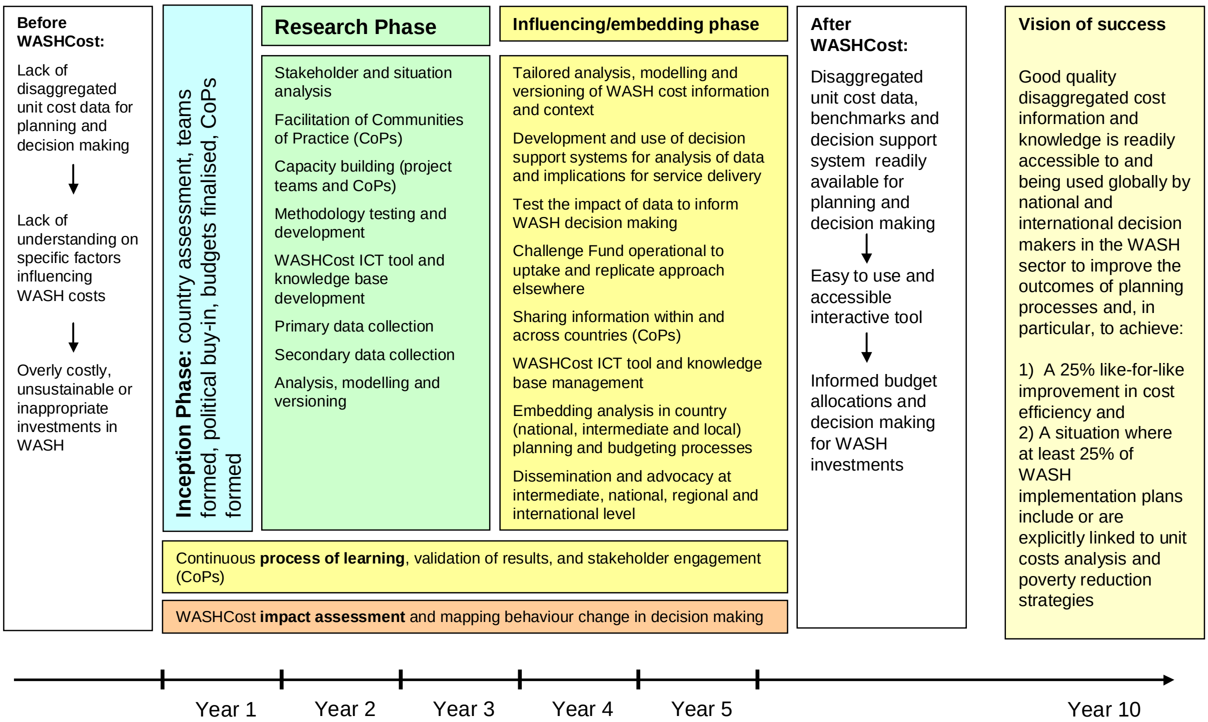
**Figure 3-2: WASHCost timeline and vision**




## 3.2 Phases of research and scheduling of activities

Research activities for this doctorate were split up into four phases spanning early 2011 to mid-2014. This sub-section gives a general timeline of key research activities over this period whereas the detailed explanation of sampling and analytical methods used are provided in subsequent sections.

The first phase of fieldwork activities ran from March to December 2011 and was focussed on achieving a clear understanding of the institutional and service delivery context in each WASHCost country as well as understanding, validating, and harmonising the data collected. The second phase, spanning most of 2013, moved onto the detailed interpretation, analysis, and comparison of each country data set in collaboration with each of the country teams. The third phase, in early 2013, was focussed on a detailed assessment on service delivery costs and functionality in rural Ghana in order to provide specific details on the required expenditure to improve service delivery (research objective 2: sub objectives 2.2 and 2.3). This component was based on a comprehensive inventory of water supply assets in two rural districts and was undertaken with financial, logistical, and technical support of the Triple-S project.

The final research activities undertaken replicated the WASHCost methodology in a new country study area in Sierra Leone. The data collected in this study has been analysed alongside the core WASHCost data making it a five country comparison of historical costs and service levels (research objective 1: sub objectives 1.1-1.4). The chronology of research activities are summarised in Table 3-1.

**Table 3-1: Chronology of research activities 2011 - 2014**

| Date | Research activities | Other activities |
|---|---|---|
| Phase 1: March – December 2011 | - Country missions to Andhra Pradesh, Ghana and Mozambique.<br>- Hosted all country "data analysis" work-shop to evaluate existing country data storage and analysis procedures.<br>- Created a centralised global database of cost and service level data. Gradual population of this database with comparable data from each country. | - Attended global WASHCost research meeting Burkina Faso<br>- Supported all country teams in data analysis of country outputs.<br>- Presented paper on sanitation cost and service levels at 2011 Water and Health conference, University of North Carolina.<br>- Wrote research paper "applying the life-cycle costs to sanitation" (Burr and Fonseca 2011). |
| Phase 2: January - December 2012 | - Participated in country visits and writing workshops with country research staff in the Netherlands, Andhra Pradesh, Ghana and Mozambique.<br>- Final validation of WASHCost data with country teams and key stakeholders.<br>- Shared global database on costs and services for use by partners and researchers. | - Provided WASHCost training of WASH staff at BRAC, Dhaka.<br>- Keynote presenter and content advisor at 28th AGUASAN workshop on: "Financial sustainability of WASH services: About mind-set change and an eye for the future".<br>- Presented research aims, objectives and provisional findings to graduate students at Anglian Water and students at Cranfield University.<br>- Wrote research paper "applying the life-cycle costs to water" (Burr and Fonseca 2012). |
| Phase 3: January – May 2013 | - Extended fieldwork in rural Ghana funded by the Triple-S project. | - Presented paper on Asset Management in Ghana - IRC Symposium 2013: Monitoring Sustainable WASH Service Delivery, Addis Ababa, Ethiopia.<br>- Wrote a chapter on data collection and analysis of life-cycle cost data for the WASHCost Book (IRC, 2014)<br>- Wrote project report "Assessing the scope for Asset Management in rural Ghana" (Burr, 2013). |

| | | |
|---|---|---|
| Phase 4: May 2013– May 2014 | - Fieldwork on the replication of WASHCost methodology in Sierra Leone in collecting data on water and sanitation costs and services – including self-supply. | - Development and piloting of data collection methodology in one district in Sierra Leone.<br>- Finalised cost mapping report "Institutional Cost Mapping related to rural and peri-urban WASH service delivery in Sierra Leone (Burr et al., 2013).<br>- Validated cost mapping report, and final research report: "Life-cycle costs of Water, Sanitation and Hygiene services in Sierra Leone" (Burr et al., 2014) with sector stakeholders. |

## 3.3 Research sample and methods

For each phase of the research separate methodologies and datasets were used. Table 3-2 outlines the entire data sample collected at each phase of the research to answer the research questions shown. The role of the researcher and therefore the methodology changed throughout these phases and these will be explored in turn, first by giving an overview of the approach to data collection, storage and processing and then by detailing the data analysis equations and statistical analysis used. The detailed breakdown of data sources and sample sizes are provided in the appropriate data analysis chapters.




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**Table 3-2: Sampling strategy and research tool used**

| Chapter | Research questions | Sampling strategy and tools | Methodology of the researcher |
|---|---|---|---|
| Chapters 4 and 5 | Historic analysis of costs and service levels across five countries<br>- What are the current levels of expenditure on water and sanitation services, and how do these vary between countries?<br>- How effective is WASH expenditure in achieving adequate and sustained levels of service?<br>- What, if any, relationships exist between unit cost expenditure and water and sanitation service levels?<br>- What can available data tell us about levels of expenditure required to provide adequate and sustained levels of service? | WASHCost core dataset<br>- A total of 10,571 household surveys undertaken in 298 communities from across the four focus WASHCost countries. This contained details of 4,077 household latrines - 3,624 with valid cost data – as well as information on water and sanitation service levels and household expenditures.<br>- Key informant interviews and document analysis at community and district level provided technical details of 1,543 borehole and handpump systems - 1,466 with valid cost data - and 196 piped water systems - 183 with valid cost data.<br>- At national levels 478 construction contracts for borehole and handpump systems and 66 construction contracts of piped systems we analysed and integrated with household data.<br><br>Replication of WASHCost in Sierra Leone<br>- A total of 2,006 household surveys: 1,264 on public water provision, 19 on water self-supply, and 723 on sanitation – were conducted across three districts in Sierra Leone.<br>- Detailed key informant interviews and infrastructure surveys were undertaken with water management teams in each of 36 communities.<br>- Secondary data provided by partner NGO InterAide relating to handpump maintenance costs.<br>- A focus group discussion facilitated by data collection consultant with self-supply technicians | WASHCost core dataset<br>- Sampling strategy and data collection by WASHCost country research teams.<br>- The researcher collated, analysed and validated this data from all the countries to undertake a comparative analysis of the core WASHCost data set.<br><br>Replication of WASHCost in Sierra Leone<br>- The sampling strategy, data collection tool and protocol developed by the researcher and used to train a consultant data collection team.<br>- The data was cleaned, validated and analysed by the researcher. |
| Chapter 6 | Ghana case study<br>- What levels of expenditure are required to provide adequate and sustained water services in rural Ghana?<br>- What is the impact of management and financing practices at community and district levels on the functionality? | - Overview analysis of comprehensive infrastructure survey of over 400 water points undertaken by Triple-S in 2011 and 2013<br>- 21 semi-structured key informant interviews with CWSA and district assemble staff.<br>- 7 focus groups conducted in small communities; 3 focus groups in small towns and 2 focus group discussions with private sector area mechanics. | - The researcher developed research tool and interview frameworks and undertook fieldwork<br>- The detailed infrastructure survey had been collected and cleaned by the Triple-S team before analysis by the researcher. |

## 3.4 Defining water and sanitation technologies

This sub-section presents and defines the different water and sanitation technologies analysed in this thesis.

In Chapter 4, all the latrines analysed are classified as a form of “on-site sanitation”. Typically on-site latrines are found in rural and small town areas of low-income countries where space and population density do not overly constrain latrine construction and where extensive sewerage networks are considered too costly and difficult to construct (Tremolet et al., 2010).

Table 3-3 displays, per country, the different on-site latrine technologies analysed in each country. This shows that amongst the African countries the data points collected relate to different types of pit latrine ranging in complexity from the “traditional pit latrine” – normally an un-lined latrine pit without a secure and impermeable squatting slab - to the “ventilated improved pit latrine” normally with a cement or brick partially-lined pit, an impermeable slab, and a ventilation pipe and screen to reduce odours and flies.

In Andhra Pradesh state all the latrines sampled are broadly classified as either a single or double pit “pour flush” latrines. These latrines are characterised as having a concrete lined pit and a sealed slab that provides a water seal separation between the user and the pit. The offset double-pit system allows for one pit to be used whilst the other can be set aside for natural treatment of the pathogens and subsequent manual emptying –therefore allowing the continued use of the latrine (Franceys et al, 1992). Examples of the latrines analysed can be found in Appendix B.2.

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**Table 3-3: Definition of latrine types and the cost data collected across the five WASHCost countries**

| Latrine type | Definition | Andhra Pradesh | Burkina Faso | Ghana | Mozambique | Sierra Leone |
|---|---|---|---|---|---|---|
| **Traditional Pit Latrine (TPL)** | A pit latrine with an insecure slab (e.g. loose pieces of wood) or no impermeable slab | - | - | ● | ● | ● |
| **Improved pit Latrine (IPL)** | A pit latrine with a secure or concrete impermeable slab | - | ● | ● | ● | ● |
| **Ventilated Improved Latrine (VIP)** | A single or double pit that is often lined with cement rings or blocks sitting below an impermeable slab. A ventilation pipe and screen are standard to reduce odours and flies. | - | ● | ● | ● | ● |
| **Pour Flush Latrine (PF)** | A concrete or brick lined single or double pit, usually offset, with a safe super structure and a sealed impermeable slab including a flushable pan. | ● | - | - | - | - |

In Chapter 5 a combination of point source and piped water systems are analysed and are summarised in Table 3-4.

Typically in the small rural communities sampled, water services are provided through boreholes with handpumps or hand-dug wells fitted with handpump systems, although these also exist (and are used) in many communities that have piped supplies. A range of small, medium and larger-scale piped water systems have also been sampled in every country except Sierra Leone. The size of these systems is determined by the number of people they are designed to serve (the size boundaries of these are shown in Table 3-4) and are notionally described as small town systems, although the difference between small towns and village/rural community is not always clear, particularly as villages grow in size and some are absorbed into the fringes of the nearest town.

By WASHCost segmentation, a mechanised borehole system has no pipe network distribution system. A single-village/town system is one where the source is developed locally and where water runs to stand-posts or households through piped networks inside the community. A multi-village/town system has water piped from an outside source serving several towns or villages. In these cases, responsibility for operating and servicing the distribution within the community is often separated from the responsibility for the major piped supply. A mixed piped supply means that there is more than one parallel system, although they may be run by the same authority and they may be part of the same service delivery model. Mixed piped supplies have more resilience in the system; one may continue to work when another breaks down.

**Table 3-4: Definition of water service technologies analysed across the five WASHCost countries**

| Service Delivery Model | Sources | Population of service area | Andhra Pradesh | Burkina Faso | Ghana | Mozambique | Sierra Leone |
|---|---|---|---|---|---|---|---|
| Self-supply: Household "EMAS" water system consisting of a hand-drilled well with a manual pump, and a storage tank. | Ground water | | | | | | • |
| Hand-dug well with handpump | Ground water | | | | | | • |
| Borehole and handpump | Ground water | | • | • | • | • | |
| Mechanized borehole (Mech BH): Water is supplied through a small distribution network and connected public stand posts. Water storage is limited, typically to an overhead storage tank directly connected to the pump. | Ground water | < 500 | • | | | | |
| | | 500-5,000 | • | • | | | |
| Single-village (town) supply (STS): Reticulated supply with pumping, storage and distribution through public stand posts with provision for house connections. | Ground water and surface water | < 500 | • | | | | |
| | | 500-5,000 | • | | • | • | |
| | | 5,001-15,000 | • | | • | • | |
| | | > 15,000 | | | • | • | |
| Multi-village (town) supply (MTS): Reticulated supply with pumping, storage and distribution supplied to a number of interconnected towns or villages. Each village with its own storage and distribution network. | | < 500 | • | | | | |
| | | 500-5,000 | • | | | | |
| | | 5,001-15,000 | • | | • | | |
| | | > 15,000 | | | • | | |
| Mixed piped supply (MPS): Water is supplied through a combination of separate, often overlapping, service delivery systems. | | < 500 | • | | | | |
| | | 500-5,000 | • | | | | |
| | | 5,001-15,000 | • | | | | |

## 3.5 Comparative analysis of costs and services

Comparative studies are a common tool to analyse the similarities and differences between events or subjects using a common analytical framework (Bryman, 2008). Comparative studies can be purely descriptive, where the differences between two results are identified and stated. Alternatively these studies can be normative, where the aim is to compare different cases and generate recommendations and findings leading to improvements in poorly performing cases (Bryman, 2008).

Inevitably most research studies tend to contain both descriptive and normative elements as is the case in this research. To address the identified knowledge gap, one important milestone of the thesis is to provide a descriptive analysis of the magnitude and variations in unit costs and service levels within and between service delivery technologies and country contexts (research objectives 1.1, 1.2 and 1.3). However building on this core analysis, this thesis also sought a normative understanding of the ways in which the existing ratio of financial inputs to service level outcomes can be improved to help bring about greater investment efficiency. This was done by identifying well performing technologies or country contexts, and by examining the relationship between expenditure and service levels (research objectives 1.4 and 2.1).

The reason for undertaking a broad comparative analysis was driven by the donor expectations. The Bill and Melinda Gates Foundation had a particular interest in understanding the costs of delivering water and sanitation to large populations in multiple locations. IRC as the project implementers also aspired to influence the international WASH community and impact the financing practices of large donors. Consequently alongside country focused activities that were responsive to the needs and areas of interest of learning alliances, a broader comparative analysis was sought in which country data sets can be analysed using a common methodology, using common indicators, and yielding comparable results that could influence the sector at large.

### 3.5.1 Describing the data set

Over a period of two years (2010-2011) data on the costs and service levels of water and sanitation systems were collected in India (Andhra Pradesh), Burkina Faso, Ghana and Mozambique by country teams that together comprised more than 100 people.

Data on costs and service levels was collected from more than 10,000 household surveys, from technical water point surveys and key informant interviews within communities. Where expenditure data was not explicitly available, information was collected by reviewing contract completion reports and by interviewing stakeholders at household, district, regional and national levels. The use of mixed data sources and mixed methodologies to collect them was consistent with the action research approach where the emphasis is placed on collecting a quantum of data that can be considered simultaneously to help answer research questions but which can to feed directly into decision making and practice (Pine, 2009; Greenwood and Levin, 1998).

Within the project a common approach to data collection, management and storage was agreed at global research team meetings and codified in the WASHCost data collection and organisation protocol (Verhoeven et al., 2010). This protocol stressed that sampling should be representative at the level of the communities, technologies and service areas where it was collected. Efforts were made to ensure that these were in turn representative of the country (or State) as a whole, or that they at least represented a range of typical service delivery areas reflecting a range of challenges.

However the precise details of the design, scope, and scale of data collection were autonomously decided by each country research team in consultation with the national level learning alliances and other key stakeholders. As a consequence the quantity and type of information that was collected varies from country to country. In Andhra Pradesh (India) and Mozambique, data collection was designed to incorporate a cross-section of cost and service in defined agro-climatic regions. The Ghana country team focused on collecting data from three broadly representative regions and the Burkina Faso country team collected very detailed data in three “communes” (this is defined as the lowest administrative level of Burkina Faso). Data was collected from more communities in India than in the other countries to meet the aspirations of the Andhra Pradesh state government and other key stakeholders to make the data more representative of this large and diverse state.

Details of the sampling methodology adopted in each WASHCost research country are available here: Ramachandrudu, (2008); Moriarty, et al. (2011); and WASHCost Mozambique, (2010). Despite the intra-country variations in sampling sizes the general approach to household cost and service level data collection was similar.

Low levels of water and sanitation “coverage” – understood as those households with access to a formal latrine or improved water service – amongst the African countries in particular would have meant that a purely random sampling methodology would have been unlikely to generate the targeted cost and service level information. In addition random sampling across entire rural district or regions, where road infrastructure is often poor, and communities dispersed would have been too costly.

Consequently a two-stage cluster sampling approach was adopted in each country. In this study this multi-stage sampling was used so that chosen households clustered geographically, first by district/region and then by community for more cost effective data collection. From within each cluster households are selected randomly, meaning they have an equal chance of being selected (Pfeffermann and Rao, 2009).

In these samples the first stage of clustering selected a number of target regions or districts according to the following criteria:

- Contain a diversity of water supply and sanitation infrastructure;
- Together the selected districts are representative of the countries different climate and hydro-geology;
- Have known programmes of government and donor investment to maximise the potential for costs and service level data.

Once the target district had been identified, specific community and small town areas were selected in consultation with local government representatives and development partners according to a second set of criteria described below.

- Presence of infrastructure in the community for a period of three of more years to increase chances of cost data availability;
- Certainty that the communities sampled are not of the same size or density to help ensure a diversity of infrastructure are sampled;
- Ensuring that the communities sampled are reasonably representative of the socio-economic context of the region/district.

Alongside the household surveys in each selected community/town, technical surveys were undertaken on the water supply systems, as well as interviews and meetings with the appropriate community based organisations in order to accumulate a quantum of information related to the operational context as well as required cost information.

Furthermore, in conjunction with local level data collection, additional specific research was undertaken with local, regional and national governments and relevant development partners to identify and quantify any historic expenditure data on delivering water and sanitation services in these areas. The sample-sizes for each country study are presented in the analysis chapters.

The data from all sources was entered manually into Excel databases formatted in local languages using non-standardised codes and managed, at least initially, by in-country data managers. The primary reason for using Excel was that it was ubiquitous software that in-country data managers were comfortable with using.

### 3.5.2 Creating a globally comparable data

As discussed in each focus country, survey designs were developed and adjusted to reflect the local context and the specific interests of country stakeholders in accordance with the learning alliance approach. However for the purposes of this thesis, this approach also presented challenges for the researcher in ensuring consistency and comparability of data collected across country contexts.

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The researcher was bought into the WASHCost project towards the end of the "research phase" after the majority of data had already been collected and the frameworks for capturing and analysing cost and service level data had already been developed. These frameworks are described in detail in section 3.7.1.

At this stage, within each of the research teams, the analysis and interpretation of this data was still in its infancy. Therefore the initial role of the researcher was to ensure that data collection, storage, and analysis protocols were being consistently applied across each country research setting; and to validate the data collected.

Throughout 2011 and 2012 the researcher spent extended periods in each of the focus countries to work directly with national staff to better understand the service delivery context and data collected. In doing so the researcher helped national staff clean, validate, and analyse the data collected. In addition, throughout this period there was daily communication between the researcher and the country teams to help resolve data queries. Any persistent uncertainties or conceptual challenges identified in data collection were raised at global research meetings of all researchers.

The largest challenge in this period was making sure that the cost and service data collected were comparable across the country contexts as well as being compatible with the corresponding cost and service level frameworks (detailed in section 3.7) that were to be the basis of the cross-country analysis.

Co-ordinating this information across disparate country teams proved difficult, despite the data collection protocol, and persistent uncertainties remained about some aspects of data collected in each country. To resolve this, in what proved to be a key moment in this research process, the researcher led a week-long global data management and analysis meeting hosted in Rotterdam. Working closely with the data managers in each country, this meeting served to harmonise the data storage, management and analysis principles across each country and also to identify and document the cost data sources and service level indicators to be used for cross-country analysis.

As a result of this workshop the researcher created a series of Microsoft Excel workbooks with common field names and coding, that were indexed to country databases and could be populated with comparable country data. These workbooks included a means to capture and make sense of data from multiple different data sources to fully reflect the breadth of data collected. These same workbooks were then used as the basis for data mining, interrogation and analysis.

These activities over an extended period culminated in the release of the core WASHCost dataset on the Data Archiving and Networked Services (DANS) web-based platform, to be reviewed, assessed and utilised by other researchers. These data sets can be accessed at: https://easy.dans.knaw.nl/ui/?wicket:bookmarkablePage=:nl.knaw.dans.easy.web.search.pages.PublicSearchResultPage&q=IRC

### 3.5.3 Relationship between country teams, the project and academic requirements

Throughout the whole period the researcher was conscious that relationships with country research teams needed to be sensitively managed to maintain local ownership of the data whilst at the same time ensuring the validity and comparability of findings for cross-country analysis. Ultimately however the only way to ensure that this data was appropriately robust and understood was to centralise much of the data management, processing, and analysis to the researcher, which inevitably somewhat limited the role of the country data managers

The researcher was also cognisant of the need to balance the action research elements of the project, with the academic rigour required for the doctoral research. Bell and Read (1998) emphasise that collaborative partnerships for a PhD study can provide advantages to the researcher, in the form of opportunities to develop professional skills and networks, and also help the research project as a whole through providing access to data sources and resources. However, Macmillan and Scott (2003) as well as Bell and Read (1998) also recognise that research partnerships can be challenging because the researcher has to simultaneously manage the needs and expectations of both academic and non-academic partners. This can put undue strain of the researcher and also means that there can be a greater risk of the non-academic partner prejudicing the results.

Onwuegbuzie (2004) argues that tendencies towards confirmation bias – where undue focus is given to findings that confirm preconceptions, or expected hypotheses – can be heightened within non-academic institutions that are keen to communicate research messages without sufficient internal or peer critique. Similarly, Burawoy (2005) cautions that types of instrumental research which emphasise the provision of findings to shape policies and practices, are more susceptible to bias results according to underlying values or assumptions about how the sector works - or what correct or incorrect policy or practice may be.

Certainly for large parts of the research period, and while the Project was in the data validation stage, the researcher primarily responded as a good employee and valued team member which was important for delivery of project outputs and also to improve information sharing and trust building across the country teams to improve the robustness of all research outputs. However in consultation with both academic and non-academic supervisors, the researcher was also given space and time to work on thesis outputs independent of any potential heuristics and biases in data analysis and presentation.

### 3.5.4 Replication of WASHCost methodology in Sierra Leone

The amount of cost and service level data collected as part of the WASHCost study was considerable. However because of the action-research approach and the different management of data in each country, it took considerable time and money to generate globally comparable data.

The long data validation and analysis process meant there were many lessons to be learnt from the data collection and analysis process of WASHCost. The researcher has documented these challenges and lessons learnt in Chapters 6 and 7 of the WASHCost project book (McIntyre et al., 2014), and applied these lessons to replicate the WASHCost methodology in Sierra Leone. This additional

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data has augmented the data collected across the four WASHCost countries – making this a five country comparative analysis.

The researcher designed the sampling strategy, methodology, and data collection tools for the work in Sierra Leone. Using a much reduced set of service delivery indicators and targeting cost research more explicitly on communities where data was likely to exist, this research was undertaken within a tighter timeframe and at a much lower cost compared to the original WASHCost studies.

The selection of the districts was aimed at having a sample that is representative of the situation in the Sierra Leone. Once again multi-stage clustered sampling was used to select districts according to:

- Geographical representation of the countries (across Northern, Southern, and Eastern regions)
- Mix and variety of water and sanitation technologies.
- Likely availability of cost data. It is important to sample systems or communities that are likely to have cost data. This may be those systems that have been functioning longer or that are known to maintain financial records.
- Motivated staff within the district's council who will help facilitate data collection in the field, and act as a crucial link between the data collection consultants and the communities.

Unlike the original WASHCost study water and sanitation data was collected from different areas depending on the likely availability of data. Based on the criteria above, the three district councils of Kenema (East), Bo (South) and Kambia (North) were selected for the collection of water cost data. Sanitation data was collected in two districts, Kenema (East) and Port Loko (North).

For the examination of water costs and service levels a second stage cluster of thirty small rural communities were sampled – ten in each district. The criteria for these rural communities were that they were supplied through either hand-dug well, borehole and handpumps, with final selection taking place in consultation with district council staff.

Within each of these community sub-clusters, thirty households were selected according to a "random walk and quota" sampling methodology. This non-probabilistic methodology avoids the costly and time-consuming expense of listing all the households in the sample area - village or cluster or segment - it is also justified on the grounds that non-response is avoided since the interviewer continues beyond non-responding households (UN, 2005).

The examination of sanitation costs and service levels was conducted in a total of twenty communities from Port Loko and Kenema districts (ten communities in each). These were selected as they were known to have recently been declared 'open defecation free' following a sanitation and hygiene intervention and were therefore known to have undertaken latrine construction. Within each of these communities, 30 household surveys were undertaken in each community.

As part of the primary data collection, interviews and financial accounting exercises were undertaken with focal point staff at the district councils, and also with WASH committee's in the communities. Whenever data gaps were encountered additional specific research was undertaken to fill these gaps. In this project the primary data collection of the project was supplemented by additional secondary data from InterAide, a French NGO working in Bombali district (Northern region), who provided a rich database on operational and capital maintenance costs for borehole with handpump and hand dug-well with handpump systems.

Separate data collection was undertaken in Kenema district, aimed at determining the life-cycle cost and service levels of self-supply water systems. The small number of households (16) that were known to have invested in these systems were purposively sampled for cost and service level information.

Given the small sample size, cost data was supplemented by a focus group discussion of self-supply technicians who constructed these systems to provide insights on the costs of construction and maintenance activities and the robustness of system components. The focus group discussion was facilitated by a local enumerator, following a guidance document (prepared by the researcher).

All primary data collection was carried out by a consultant data collection team – "Dalan Consult". Further details of the collection methodology, guidelines for community entry, confidentiality, and research tools used for WASHCost Sierra Leone can be found in Appendix 0.

The collation and comparison of cost and service level data across five-countries primarily sought to provide the sector with an international overview of effectiveness of current levels of expenditure and current supply technologies at delivering water and sanitation services. A second order objective was to be able to provide better understanding of the level of expenditure that is required to ensure the continuity of delivery of "basic" services. This was done in two ways.

The first approach is based on the analysis and interpretation of the core WASHCost data. Specifically this dealt with the identification of trends between the levels of capital and recurrent expenditure between technologies, country contexts and the level of water or sanitation service delivered. This is a general assessment based on the aggregated data of five country studies (research objective 2.1).

The second approach is based on a detailed case study of the cost and management of water services in two rural districts of Ghana, it is to this section that this chapter now turns.

## 3.6 Detailed case study of rural water costs in Ghana

The five country comparative analysis presented in Chapters 5 and 6 operated out of necessity at a level of aggregation which meant that relationships between the unit costs expenditure, service levels, and context specific factors of how systems are managed, financed, and maintained could not be systematically explored.

In order to access these context specific issues this thesis provided a detailed case study analysis which focused on comparing the functionality of rural water points in Ghana to how these systems are being managed, maintained and financed by community based organisations, and in turn how these communities are being supported by local government service authorities. A sophisticated understanding of the inter-relationship between expenditure, management and water point functionality was the basis for a more precise understanding of the sufficiency or otherwise of current expenditure and of the required expenditure to sustain rural water services (research objectives 2.2 and 2.3).

The case study approach was chosen as the best means by which to address the more complicated and detailed aspects of this chapter, namely "how" different processes work and "why" different phenomenon occur (Burns, 1990; Yin, 2003). Two case study districts were selected in rural Ghana, Akatsi District in the Volta region and East Gonja in the Northern region. The research for this chapter was undertaken in collaboration and financial support of the Sustainable Services at Scale project (Triple-S) also hosted at IRC.

Conceptually this chapter builds upon the WASHCost approach through comparative analysis of existing expenditure and practices against a measure of the services delivered to users. The primary enhancement on the WASHCost approach is that indicators of the management of each water point have been collected, as well as detailed information from the field of financing arrangement at both community and district levels. These factors are assessed alongside more detailed technical assessment of the functionality and condition of the system.

The analysis in Ghana is founded upon two main data sources.

The first is a comprehensive inventory of rural water supply assets collected by the "Triple-S" project in the two case study districts. This dataset provided detailed indicators of asset functionality as well as information on the technical and financial management of water services by local and district service providers, collected first in 2011, and once again in 2013. At the time of data analysis both the 2011 and 2013 data sets had been collected and validated by the Triple-S team[8].

[8] The 2011 asset inventory data has been used for project purposes reporting on the status of rural water supply services in Ghana (Adank et al., 2013). The collation of asset inventory data from both years, and the analyses relationships between expenditure, management, support, and functionality is unique to this this thesis.

The indicators collected at community and water point level are summarised in Table 3-5. Together these indicators have been used to provide a detailed overview of the current status of how assets are being managed and financed within rural communities, and how these communities are being supported by district councils.

**Table 3-5: Financial management and technical indicators collected in the community**

| Indicator | Type of indicator | Possible answers |
|---|---|---|
| Is the water point functional? | Technical | Functional, Partially functional, Non-functional, Broken Down. Defined by stoke and leakage tests (explained in section 3.7) |
| How old is the water point? | Technical | Numeric |
| Are water points being managed by Water and Sanitation committee? | Management | Yes, No, No data |
| Does the community charge a tariff? | Management | "Pay as you fetch", Monthly, No tariff, No data |
| Has the community received a visit from a district assembly representative in the past year? | Support | Yes, No, No data |
| Does the community undertake periodic/preventative maintenance? | Management | Yes, No, No data |
| Does the community undertake corrective maintenance? | Management | Yes, No, No data |
| How much did the community spend on maintenance in the last year? | Financial | Numeric |
| If the system is non-functional why has it not been repaired? | Technical/ management | Lack of funds, Lack of spare parts, Can't engage a technician, Low yielding water point, Other, Don't Know |
| Has the water point been rehabilitated? | Management | Yes, No, No data |
| Which organisation financed the rehabilitation? | Financial | String |
| How much was the rehabilitation? | Financial | Numeric |

The second source of data came as a result of the researcher's field work in rural Ghana between January and February 2013. The purpose of this fieldwork was to provide a critical understanding of the institutional, community and social-economic factors which influence how water systems are managed and financed within rural communities and also to determine empirical evidence of this financing.

To achieve these fieldwork objectives the researcher conducted 21 semi-structured key informant interviews with a cross section of district assembly and CWSA staff; 7 site visits and focus groups conducted in small communities; and 2 focus group discussions with private sector area mechanics. A summary of the interviews conducted and communities visited can be seen in Appendix C.3.

The semi-structured interviews at national and regional level were recorded and transcribed and conducted with reference to a pre-written outline to ensure all key topics were covered. Questions tended to be open ended and in conversational style to help encourage participation from the interviewee and for them to speak in their own style (Yin, 2003; Flick, 2006). Community level interviews followed these same principals but were translated by district assembly staff - this meant the discourse was sometimes more fragmented. The choice of interviewee was made using snowball sampling starting with members of the Triple-S team and CWSA staff at the head office. At district and community level a key resource in data collection were the Environmental Health Assistants (EHAs) working at the District assemblies. These acted as gatekeepers of knowledge and help co-ordinate community visits and interviews.

Throughout the key informant interviews it was made explicit to all participants that the research activities undertaken were independent from the project work of Triple - S. To this extent the researcher follows the advice of Mercer (2006) that, at appropriate times, the researcher should seek an independent identity from NGOs or implementing partners to effectively manage the expectations of participants.

Due to time and resource constraints, the communities that the researcher visited were selected purposively according to areas where district staff expected to provide better informants and quantitative data. For this reason the communities may not have been representative of either the water and sanitation management teams for small communities. To ensure a more representative picture of the

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district, focus group discussions were conducted with district Environmental Health Assistants with the specific aim to access these broader issues.

## 3.7 Data analysis process

Having outlined the different data sources and data collection methodologies used in this thesis, this section now turns to different steps of data processing and analysis used in each of the chapters. Specifically this covers three areas:

- The calculation of water and sanitation service levels (for Chapters 4 and 5), and the calculating water point functionality (Chapter 6);
- Treatment of historical expenditure to make values comparable between countries;
- Simple methodologies for calculating and determining the required costs to sustain services.

### 3.7.1 Calculating service levels

A core element of the WASHCost methodology was that the sufficiency or otherwise of expenditure can only be adequately assessed in relation to the level of service that is being delivered.

The key indicators of a water and sanitation service in the literature have been discussed at length in section 2.4. The WASHCost service ladders have distilled the characteristics of water and sanitation services into four key indicators.

For sanitation these indicators are:

- accessibility of the sanitation facilities to the household;
- use of sanitation facilities by members of the household;
- cleanliness, maintenance and pit emptying of the facilities; and
- environmental safety of faecal waste

Each indicator has been sub-divided in three or four defined levels forming different rungs of a service ladder ranging from “no service” to “improved” service (Table 3-6) (Potter et al., 2011).

The service level for each household is determined by the lowest service level scoring (or rung), therefore if any one of these indicators does not reach this “basic” standard, the overall service is considered to be at the level of the worst performing indicator. The same logic applies for the water service ladders.

**Table 3-6: WASHCost sanitation service levels**

| **Service levels** | **Accessibility** | **Use** | **Reliability** | **Environmental protection (pollution and density)** |
|---|---|---|---|---|
| “Improved service” | Private household latrine with impermeable slab | Facilities used by all members of Household | Regular or routine Operations &Maintenance (inc. pit emptying) requiring minimal user effort | Non problematic environmental impact disposal and re-use of safe-by products |
| “Basic service” | Shared latrine with impermeable slab at national norm distance from household | Facilities used by some members of household | Unreliable O&M (inc. pit emptying) and requiring high user effort | Non problematic environmental impact and safe disposal |
| “Limited service” | Platform without (impermeable) slab separated faeces from users | No or insufficient use | No O&M (pit emptying) taking place and any extremely dirty toilet | Significant environmental pollution, increasing with increased population density |
| “No service” | No separation between user and faeces, e.g. open defecation | | | |

The service ladder framework provided the guiding framework for collecting and analysing sanitation services. The manner in which service level questions were posed was not identical across each country context and bears further explanation.

The “accessibility” indicator was the only service level data that was collected in precisely the same manner across the countries. In terms of environmental safety of faecal waste disposal, data cleaning identified inconsistent responses amongst enumerators. Further discussion revealed that in many cases enumerators did not feel confident in assessing the environmental safety of different modes of

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faecal waste disposal. Consequently this indicator has been excluded from the cross-country service level analysis. Information on latrine use and reliability was collected in each country, although there were slight variations in how questions were posed and answers recorded. Table 3-7 documents these variations. In general these are considered sufficiently minor so as to not greatly skew service level analysis – the one exception is the “use” indicator in Mozambique which is considered more lenient than the same indicator in the other countries.

**Table 3-7: Calculation of sanitation service levels per country**

<table>
<tr><th>Country</th><th>Accessibility</th><th>Use</th><th>Reliability</th></tr>
<tr><td>India</td><td rowspan="5">All countries collected indicators of latrine characteristics. A private household latrine with a secure/impermeable slab corresponds to an “improved service”; if the latrine is shared then “basic service”, if an insecure/no slab then a “limited service”.</td><td rowspan="3">Detailed information on the different household members using the latrine. If all family members use the latrine this corresponds to an “improved service”, if more than half the household use the latrines this is classified as a “basic” service. If less than half of household members this was deemed to be “no service”.</td><td>No information of latrine cleanliness was available. If cleaning and maintenance was regular (monthly or more) it was considered a “basic” service. If maintenance was irregular or not happening this was considered a “limited” service.</td></tr>
<tr><td>Burkina Faso</td><td rowspan="2">Based on observations of latrine cleanliness and the safety of pit emptying.</td></tr>
<tr><td>Ghana</td></tr>
<tr><td>Mozambique</td><td>Only the household heads were asked if they were using/not using the latrine - 99% of respondents said they used the latrines</td><td>Based enumerator observations of latrine cleanliness 3 service level given.</td></tr>
<tr><td>Sierra Leone</td><td>Same as Andhra Pradesh.</td><td>Based on indicators of cleanliness including presence of odour and flies. More information allowed these to be subdivided in to limited and no service</td></tr>
</table>

For water the four identified service indicators of a “basic” service are:

- people access a minimum of 20 litres per person per day;
- water is of acceptable quality (judged by user perception and country standards);

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- water is drawn from an improved source, which functions at least 350 days a year without serious breakdowns; and
- people spend no more than 30 minutes per day per round trip (including waiting time) to access water.

Each of these indicators is sub-divided into between four and five rungs of the ladder ranging from “no service” through to “high service” (Moriarty et al., 2012).

**Table 3-8: WASHCost water service levels**

<table>
<tr><th>Service levels</th><th>Quantity</th><th>Quality</th><th>Accessibility distance and crowding</th><th>Reliability</th></tr>
<tr><td>High</td><td>>= 60 Litres per person per day</td><td>Meets or exceeds national norms based on regular testing</td><td>Less than 10 minutes per round trip.<br>(Or alternatively water available in the compound or HH)</td><td>Very reliable = works all the time</td></tr>
<tr><td>Intermediate</td><td>>= 40 Litres per person per day</td><td rowspan="2">Acceptable user perception and meets/exceeds national norms based on occasional testing</td><td rowspan="2">Between 10 and 30 minutes per round trip.<br>(Or alternatively less than 500m to source AND less than design population per functioning</td><td rowspan="2">Reliable/secure = works most of the time (Non-functional between 1 – 11 days per year)</td></tr>
<tr><td>Basic</td><td>>= 20 Litres per person per day</td></tr>
<tr><td>Sub-standard</td><td>>= 5 Litres per person per day</td><td>Negative user perception and/or no testing</td><td>Between 30 and 60 minutes per round trip<br>(Or alternatively between 500m and 1,000 meters to source OR more than normative population per functioning water point)</td><td>Problematic =Suffers significant breakdowns and slow repairs (Non-functional between 12 – 17 days per year)</td></tr>
<tr><td>No service</td><td><5 Litres per person per day</td><td>Fails to meet national norms</td><td>More than 60min per round trip<br>(Or alternatively more than 1,000m from the household)</td><td>Unreliable/insecure = completely broken down (Non-functional >18 days per year)</td></tr>
</table>

For the most part the core indicators for the water ladder were collected systematically between the five country studies, although some slight differences do occur. Water quality testing was not undertaken for all water points and therefore this indicator is based on user perception. For the accessibility indicator in Ghana and Burkina Faso this was based on the distance from the water point, whereas elsewhere the time per round trip was given.

The water and sanitation service ladders are used as an arbiter of service delivery standards in the analyses presented in Chapters 4 (on sanitation) and Chapter 5 (on water). In accordance with the health economics literature presented in the literature review, improvements in either water or sanitation service levels is deemed to have a positive effect on the health and livelihood of the household members – all other things being equal – which represents an indicator of the "efficiency" of investment.

This inventory was not however accompanied by household surveys so a service level analysis is not possible. Instead effectiveness of water points was determined according to their functionality. Technical assessments at each water point determined water point functionality through the stroke and leakage tests. The stoke test measures the number of strokes of a handpump to fill a size 34 bucket (20 litres) within 1 minute. To pass the stoke test the bucket must be filled by no more than 40 strokes for the Afridev and Ghana Modified India Mark II handpumps and no more than 30 strokes for Nira AF-85 hand pumps. For the leakage test, pumping is resumed after 5 minutes rest following the stroke test. If water flows from the hand pump within 5 strokes, the pump has passed the leakage test. If the borehole with handpump fails both of these tests it is classed as "non-functional", if it fails one of these test it is classed as "partially functional" and if it passes both it is classed as "functional". If the tests could not be performed because the pump was broken, or no water was produced after 2 minutes of pumping, the system was classified as "broken down".

To make data comparable between countries various calculation steps were followed: bringing data to a current cost value in US dollars ($), calculating annual

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recurrent expenditure for the different costs components and converting costs into per person values.

### 3.7.2 Defining service delivery costs

As highlighted in the discussion of service delivery costs in section 2.2.4, this thesis analyses and classifies the costs of delivering water and sanitation services using the “life-cycle costs” framework developed by WASHCost (Table 2-3). Noting that it does not follow the conventional ‘cradle to grave’ approach of ‘life-cycle’ costing of assets. The framework developed then adapts the terminology used by the economic water regulator for England and Wales - Ofwat, along with similar approaches to ‘regulatory accounting’, to understand the costs of urban water and sanitation service provision to make it relevant to the rural WASH sector. Taken together the life-cycle costs framework captures the aggregate financial costs of ensuring delivery of sustainable water, sanitation and hygiene services (Fonseca et al. 2011).

As part of the cross-comparison of country data a lot time was spent systematically categorising collected cost data in to the appropriate “life-cycle” cost category. In some cases this was a simple task as the source and purpose of expenditure was recorded. In other cases detailed contextual information was unavailable and consequently the classification of these costs was determined on a case by case basis in consultation with country teams.

### 3.7.3 Bringing all data to their “current cost” value

Within each country expenditure information was collected at various dates, including various unit costs incurred several years earlier. Due to the effects of price inflation, for these costs to be comparable they need to be brought to their current cost at common base year (Griffiths and Wall, 2012). This conversion was undertaken using Gross Domestic Product (GDP) deflators available for each country from the World Bank data repository[9] and all financial data was bought to current cost value, base year 2012 (Equation 1).

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[9] http://databank.worldbank.org/ddp/home.do.

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**Equation 1**

$$\boldsymbol{Local\ currency}_{(\boldsymbol{current\ costs}\ 2012)} = \boldsymbol{Local\ currency}_{(\boldsymbol{year\ x})} {}^{*}\ \boldsymbol{Deflator\ multiplyer}_{(\boldsymbol{year\ x\ @\ base\ year}\ 2012)}$$

Once adjusted to current costs in the local currency, expenditure values were converted to US$ using official market exchange rates for 2012 – also available from the World Bank "databank" (Equation 2).

**Equation 2**

$$US\ \$_{(current\ costs\ 2012)} = \frac{Local\ currency_{(current\ costs\ 2012)}}{2012\ exchange\ rate_{(local\ currency\ per\ US\$)}}$$

All data presented in the study at current costs US$ 2012 unless expressly stated.

### 3.7.4 Annualising recurrent expenditure

The recurrent costs of operational expenditure (OpEx), direct and indirect support (ExpDS/ ExpIDS) and the cost of capital (CoC) are typically accounted for as an annual expenditure. Where data was collected over a number of years, expenditure in each year was bought to its current cost value (Equation 1), and divided by the number of years of available data.

Capital maintenance expenditure ('CapManEx[10]') does not necessarily occur annually for individual water or sanitation systems, particularly not in the early years of operations – although effective budgeting processes may take a value of the presumed depreciation of an asset as an operating expense. For this reason CapManEx values can be highly variable. For this research, capital maintenance expenditure, where found, has been annualised by dividing the total reported CapManEx amount by the age of the system at the time of data collection.

Some rural systems may have been financed through loans from multi-lateral development agencies. A limited number were privately financed. In both cases the providers of the loans and/ or the providers of investment equity (the owners

[10] Particular terminology used in WASHCost in order to track global take-up of concepts and approaches

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or shareholders of private systems) have to be compensated through interest and/or dividend payments. This is termed as the cost of capital.

Once recurrent expenditures were annualised, values were converted to per person values (therefore giving expenditure per person, per year). These calculations operated differently for different recurrent costs components.

Expenditures on direct and indirect support were most often collected as lump sum values relating to expenditure at different governance levels. For example expenditure by district councils is attributed to the number of people in that district, whereas expenditure on national policy making is attributed to everyone in the country. Therefore to bring this to a per person expenditure, each annual support cost allocation has been divided by the number of people in the relevant geographical area at national, regional or district level. The analysis was also conscious of the need to ensure that expenditure at different governance levels was not double counted (for example counting both national government dispersals to regions and subsequent dispersal by regions to districts etc…) by tracking government and donor expenditure to the lowest governance level (normally district councils/assemblies).

Operational expenditure and capital maintenance expenditure values could be attributed to identified water and sanitation systems. In the case of sanitation the number of people in the household(s) accessing the latrine was systematically collected and therefore per person expenditure was calculated by taking the annual expenditure on a system (or group of systems) divided by the total number of people in those households accessing the system (or group of systems).

In the case of water systems one common difficulty was that information regarding the number of people using the system was unknown. Consequently a distinction has been drawn between expenditure per person (actual) – that is expenditure divided by the number of people using the systems – and expenditure per person (design/assumed) – meaning expenditure divided by the number of people the system was designed to serve according to its design capacity or the number of people it is assumed to serve according to national norms.

Taken together, these costs—OpEx, CapManEx, ExpDs, ExpIDs and the cost of capital— constitute total annual recurrent expenditure.

### 3.7.5 Statistical analysis

The different sampling methodology of the country teams also impacted upon the statistical analysis of the data. The different data collection strategy in each country resulted in an unbalanced data sample.

In the sanitation chapter, the majority of cost data were collected at household levels and are the basis of the statistical comparison between the service delivery costs. Separate statistical comparisons were made between categorical independent variables (technology type, rural / small town, country location) and the continuous dependent variables (capital expenditure, recurrent expenditure). Usually these types of statistical comparisons would be made using the one-way ANOVA, however this test was not deemed appropriate because:

- The considerable skew of the data (>1.5 in all cases). A characteristic of the sanitation data is that in most cases, a large proportion of households were found to spend little or nothing on latrine construction or maintenance, whereas a minority were found to be spending considerable amounts.
- The profound difference in the quantity of cost data collected in each country.

In these conditions performing one-way ANOVA could give inaccurate or erroneous results (McDonald, 2009).

As a consequence the Kruskal Wallis test was used to assess the significance of differences between median cost values. Kruskal-Wallis is a non-parametric test used to compare values for independent and randomly sampled groups (Pallant, 2005). Instead of focusing on the precise value of each data point, the data points are ranked from the smallest rank (given a rank of 1) to the highest (given the highest rank i.e. the total number of values in all groups).

The variation between the mean ranks of the different grouping are then calculated (adjusted for ties) as the test statistic H (which given the larger sample size in this study is treated as the chi-squared). The higher the H test statistic corresponds to a greater discrepancy between ranks, and these are considered significant if they are higher than critical value of H at an alpha of 0.05.

In those cases where the Kruskal Wallis test shows a significant difference between the data samples, the Dunn's test (sometime just referred to as the Kruskal Wallis post hoc test) was used to test where statistical differences could be found. For multiple-comparison the alpha was adjusted to its Bonferroni corrected value according to the number of comparisons being made. Groups are then compared according to the differences in the mean ranks between groups (Daniel, 1990).

When the number of comparisons increases the Bonferroni correction can become overly conservative, this results in Type II errors (showing false negative relationships). For this reason this post hoc test is only carried out when the number of data sample being compared is less than or equal to 5.

The investigations of water costs were also different. Whereas the data subject to statistical analysis in the sanitation chapter came from a single source in all countries (households), for the water chapter cost data has been sourced and combined from a variety of different household, government, NGO and donor sources. This reflects the diverse ways in which water systems are managed and financed across countries contexts which means that different costs are incurred by different actors at different times. It also reflects one of the concerns expressed by Kristine Komvives, an international advisor to the WASHCost project, at one of the induction meetings:

*There is a reason why cost information out there is so scattered and diverse and difficult to interpret — because it really is scattered and diverse and really will be difficult* (quoted in McIntyre et al., 2014)

An approach adopted by the project was therefore to collect as much data as possible from different sources to then triangulate these costs to get a more complete view of service delivery costs. However it also meant that the comparison of this data is not conducive to the same statistical tests as the sanitation chapter, and is instead explores the difference between expenditures through descriptive statistics and inter-quartile range values.

## 3.8 Limitations

The scale of the WASHCost project meant that a detailed database of costs and service levels could be collected across diverse country contexts. However this diversity, as well as the country ownership of data collection process, created some uncertainty when comparing costs and indicators between country contexts.

The service level section (3.7.1) has already documented differences in how these indicators were collected, limiting the direct comparability of this data. Within each country context, variations in how services were managed and financed also meant that sources of costs data varied between each country and between each water and sanitation technology. Much of this data had to be collected through close collaboration with community and local government stakeholders and the examination of often poorly maintained financial records. Unsurprisingly the records provided a mixture of data, some of which were disaggregated by activity supported by matching receipts and others simply reported as lump sum values with little supporting data.

At the point of data collection enumerators were supposed to give data a single reliability score as either “well established”; “established but incomplete”, “conflicting data”, or “expert judgement/estimation” (Verhoeven et al., 2010), however this typology was rarely followed. Instead the validity of individual data sources was assessed after a data validation process (explained later in the chapter). This process helped improve the accuracy of the data collected but it remained difficult to conclusively ascertain whether cross-country comparisons are being made using complete or partial cost data.

The researcher was not part of the research design or original data collection process for the core four-country WASHCost dataset. Consequently when cleaning and validating this data with the country teams, there was only limited scope to verify paper-based sources through comparison with documentation in

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the field. The exception to this was in India where data collection had been most extensive and validation of data was most challenging due to staff turnover in the team. In this context, the researcher visited a sample of four communities close to the state capital Hyderabad to assess the consistency of information collected in relation to the quantity, and location of infrastructure. Further data interrogation was undertaken in collaboration with country data managers as part of an iterative data cleaning and validation. Country databases were also subject to peer review process between the country teams. However despite these exhaustive processes uncertainty remains.

In terms of the water analysis, the biggest source of uncertainty with the processing and analysing of cost data is associated with how community members access and use formal water sources. The capital and recurrent costs of water systems were compared across technologies and countries as a cost per person. However the complexity of water service delivery in the communities sampled means it was often very challenging to ascertain the number of people accessing the system and this can have a significant impact on cost findings. In most cases the number of system users was determined through community and households surveys which pinpoint the number of household using a particular system as their "primary" water source. However in India the considerable water supply infrastructure at household level, and within communities, means that households access multiple different formal sources at different times of the day for different purposes and therefore the number of users cannot be attributed to any single water supply technology, or system. As a consequence the costs and service levels of water systems in India are undertaken at the community level where the mix of technologies supplying the community have been defined and categorised.

In other cases a rich dataset of costs was collected from contract sources or information from partners, but this was not supported by community data detailing the number of system users. In these cases the number of people accessing the system was assumed. In the case of borehole and handpump systems, this was done according to the national norm number of users of the system, and in the case of piped systems, it was the number of people the system is designed to serve. As a consequence it is possible assumptions may erroneously over-estimate or under-estimate the per person costs of these systems compared to the field data collected.

Exchange rate fluctuations, as well as fluctuations in the GDP deflator calculations can distort the comparison of costs between countries (De Witte and Marques, 2007). Furthermore specific currencies may be either under or over valued in relation to the US dollar. One way to adjust for this is the use of purchasing power parity (PPP) exchange rates as oppose to market exchange rates to compare costs and expenditures. The PPP rates take into account the relative cost of living and inflation in different countries to determine the purchasing power of a particular currency according to a pre-defined “basket of goods” (Griffiths and Wall, 2012). However it must also be borne in mind that the prices of the goods in the basket, such as food, housing or entertainment activities, also vary unpredictably between countries distorting cross-country comparison at PPP values (Krugman, 2009).

Conversion factors to transform each of the country costs values into PPP equivalent shows that in India, Burkina Faso, Mozambique and Sierra Leone the purchasing power of a US$ is similar (at between 2 and 3 times greater). The exception is Ghana where the purchasing power of the dollar is less (around 1.5 times greater). For coherence of results, and because conversion factors do not differ greatly between most of the countries sampled, PPP values are not included in the empirical analysis but considerations of the implication of the purchasing power of the different currencies are included as part of discussion and conclusion sections.

In terms of sanitation, equivalent latrine “technologies” were found to vary considerably in their construction quality, dimensions and specifications as a result of local geographical and socio-economic circumstance. The range of variations between latrine characteristics (especially those which were low cost in the African countries) could not be adequately captured in a limited range of technology typologies, reducing their explanatory value. The only study where sufficient details of latrine characteristics were captured was in Sierra Leone, which allowed a more detailed analysis of technologies and service levels.

Service level indicators were collected only once, consequently service level calculations only represent a snapshot of how services are delivered at a given point in time. These may not, therefore, be representative of typical service delivery in the sampled areas. Some of these challenges have been mitigated within data collection; for example households were required to estimate the quantity of water accessed in wet and dry seasons, with the average taken of the two. Similarly the reliability indicator assessed functionality over the previous year to introduce a clearer understanding of service delivery over time.

Additional uncertainty relates to enumerator observations of latrine cleanliness in the sanitation service ladder, as well as user perception of water quality are very subjective measures and will vary according to the enumerator. The interrogation of data examined patterns of responses collected by each enumerator and no systematic patterns were identified within the country studies, however the observations of latrine cleanliness in Mozambique were found to be consistently, and potentially erroneously, more favourable than the other countries.

One specific limitation has been the absence of reliable information on the cost of capital (expenditure on interest payments on loans). Occasional and anecdotal evidence was collected by country teams, however this was not widely available and has not been included in the main analysis. More generally, in countries where services are normally financed from government revenue or by transfers from donors or by NGOs, and to a lesser extent by user fees, there has been little reliance on loans that require interest payments to be made. The cost of capital remains an important concept as countries move towards financing water services themselves, but this did not emerge as a significant cost in the data collected.

Similarly the costs related to indirect support - those related to the macro-level enabling environment including planning and policy making - were not systematically collected. In the WASHCost project methodology, as part of the life-cycle costing framework, the quantification of indirect support is considered important as a means to reflect back to the sector that a good institutional and enabling environment comes at a defined cost that should be accounted for. However, identifying and collecting these macro-level expenditures from governments and donors has proved very difficult and hard to reconcile and attribute to service delivery on the ground. These costs have therefore not been included in this analysis.

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# 4 Rural and small town sanitation costs

## 4.1 Introduction

This Chapter provides empirical findings on a) the amount that has been spent to construct and maintain different types of latrines across five lower-income countries: Burkina Faso, Ghana, Mozambique, Sierra Leone, and India (Andhra Pradesh state); and b) the corresponding levels of "sanitation service[11]" different types of toilet facilities are delivering to households in the different country contexts. These findings relate to research objectives 1.1 and 1.2.

Further empirical analysis of cost and service level data examines the relationships between the type, location, and expenditure on the latrines compared to the level of service they provide to households (research objectives 1.3 and 1.4) and ultimately seeks to provide insights in to the appropriate level of expenditure required to deliver improved and sustained sanitation services (research objective 2.1).

## 4.2 Latrine financing

In the countries that were surveyed, rudimentary construction of traditional pit latrines was financed entirely by households.

For more formalised latrines, and in certain areas, all or some of initial capital costs were subsidised as part of national government or targeted NGO programmes. In Andhra Pradesh state subsidies were extended to "below poverty line" households as part of the nationwide Total Sanitation Campaign. Of the sampled households with a latrine, seventeen per cent had received a government subsidy for construction amounting to a median of $56 per flush latrine in rural areas to $85 per latrine in small town areas. In the analysis presented in this section expenditures of household and state government are combined. The disaggregated expenditure by each households and government are shown in Appendix D.1.

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[11] According to the WASHCost sanitation service levels

The improved pit latrines sampled in Mozambique are characterised by the use of locally constructed, unreinforced, domed concrete slabs to separate users from the pits. These have been produced at large scale since the late 1980s as part of the National Sanitation Programme, which has particularly focussed on ensuring these are available in peri-urban areas and small towns. At different points in time these slabs have been subsidised by as much as 80% for all users, and provided for free to vulnerable households (Colin, 2002). However during household surveys the data collection team in Mozambique did not systematically assess whether the construction costs of latrine had been subsidised either directly, with construction materials or funds directly given to households, or indirectly, with the household buying the slab at a subsidised price. The data validation and cleaning process was unable to adequately differentiate between subsidised and un-subsidised latrines. Consequently analysis presents the stated expenditure of the household recognising this may not reflect subsidised cost of a domed slab – estimated at $18 (details of this estimation are shown in Appendix D.4).

## 4.3 Data sample

The details of the number of latrines sampled and the cost data point collected are shown in Table 4-1. The majority of data points were collected in rural areas (77%) and over half (60%) were collected in Andhra Pradesh state, where the scope and scale of household data collection was much greater that the four other countries.

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**Table 4-1: Number of latrines sampled in each country study area**

| Country | Type of data | Nº of data points in rural areas | Nº of data points in small town areas | Total |
|---|---|---|---|---|
| Andhra Pradesh (India) | Capital expenditure | 1,863 | 295 | 2,158 |
| | Recurrent expenditure | 1,857 | 295 | 2,152 |
| Burkina Faso | Capital expenditure | 152 | 143 | 295 |
| | Recurrent expenditure | 164 | 174 | 238 |
| Ghana | Capital expenditure | 16 | 17 | 33 |
| | Recurrent expenditure | 42 | 7 | 49 |
| Mozambique | Capital expenditure | 532 | 352 | 884 |
| | Recurrent expenditure | 542 | 384 | 926 |
| Sierra Leone | Capital expenditure | 242 | No data | 242 |
| | Recurrent expenditure | 150 | No data | 150 |

Table 4-2 details the number of household surveys conducted in each country. This illustrates that the amount of cost data collected from households varied greatly between each country. These different response rates are symptomatic of the different sampling methodologies and data collection tools used in each country.

**Table 4-2: Number of households sampled per study area**

| Country | Detailed household surveys undertaken | Nº of households with a latrine | Nº of households with latrines and cost data[12] |
|---|---|---|---|
| Andhra Pradesh (India) | 5,743 | 2,252 (39%) | 2,158 (96%) |
| Burkina Faso | 546 | 477 (87%) | 295 (62%) |
| Ghana | 1,273 | 343 (27%) | 49 (14%) |
| Mozambique | 1,710 | 1,101 (64%) | 926 (84%) |
| Sierra Leone | 723 | 525 (73%) | 242 (46%) |

[12] Note that this figure refers to households providing any kind of latrine costs – whether this be capital, operational or maintenance expenditure and even if they are stated as zero.

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### 4.3.1 Characteristics of the data

The collected capital and recurrent expenditures are not normally distributed with data tending to have a positive skewness value (>1.5) meaning that when the data is visualised on a histogram, the mass of the distribution is concentrated towards the left (amongst the lower values).

As a consequence of the large sample size variation and the non-normality of the data sets, the Kruskal Wallis significance test was used to assess whether there are significant differences between the cost data samples. In those cases where the Kruskal Wallis test shows a significant difference between the data samples the post-hoc Bonferroni correction is then applied to establish where this difference lies. When the number of comparisons increases the Bonferroni correction can become overly conservative resulting in Type II errors (showing false negative relationships). For this reason this post hoc test is only carried out when the number of data sample being compared is less than or equal to 5.

To achieve a systematic reporting of the capital and recurrent costs and to illustrate differences between latrine technologies and between countries, this chapter adopts the following structure. For each country a descriptive statistics overview is given of the capital costs of latrines followed by an examination of the significance of costs differences between latrine types (the supporting data to this statistical analysis can be found in Appendix D.2). These per country capital costs are then aggregated and compared against the expenditure values in other countries at their current costs in US$ (2012). This same structure is then followed for the reporting of the recurrent expenditure for latrines within and between countries.

## 4.4 Capital Expenditure

### 4.4.1 Capital expenditure per latrine technology in Andhra Pradesh

Across Andhra Pradesh, the capital expenditure on latrines ranged from a minimum of $0 – signifying that the household has sourced the materials for the latrines from local free sources and constructed the latrine with their own labour – to a maximum of $1,707. The inter-quartile range of capital expenditure on all latrines was $125 - $155 (median $181), although a minority of households do spend much more, with 91 households (4%) having spent over $500 constructing their latrine (Table 4-3)

**Table 4-3: Descriptive overview of capital expenditure on latrines in Andhra Pradesh**

| **Descriptive statistics** | **Single pit pour flush latrine (Rural)** | **Double pit pour flush latrine (Rural)** | **Single pit pour flush latrine (Town)** | **Double pit pour flush latrine (Town)** | **All latrines** |
|---|---|---|---|---|---|
| Count | 1,776 | 87 | 248 | 47 | 2,158 |
| Min | $0 | $43 | $63 | $65 | $0 |
| Max | $1,707 | $797 | $1,217 | $514 | $1,707 |
| 1st quartile | $118 | $149 | $169 | $140 | $125 |
| **Median** | **$172** | **$188** | **$216** | **$194** | **$181** |
| 3rd quartile | $243 | $279 | $304 | $272 | $255 |
| Mean | $202 | $229 | $262 | $210 | $211 |
| StDev | $143 | $142 | $172 | $110 | $147 |

The Kruskal-Wallis test was used to assess the impact of latrine type and area type (rural and small town) on construction costs. Capital expenditure was shown to vary significantly between the four different technologies ($p<0.05$). Specifically, the cost of single pit flush latrines in towns is significantly higher than those in rural areas as shown by the Bonferroni adjusted p-value of 0.008 (median $216 vs. $172). There are no significant differences in expenditure between double pit and single pit pour-flush latrines across town and rural areas.

### 4.4.2 Capital expenditure per latrine technology in Burkina Faso

In Burkina Faso the median capital cost of latrines was $88, although costs were shown to be highly varied between different latrine types. The least cost ventilated improved pit latrine, for example, was found to cost $341, nearly twice that of the most expensive rural improved pit latrine (median $181); additionally the median expenditure an improved rural pit latrine ($54) is shown to be less than a tenth of the median expenditure on a ventilated improved pit latrine in town areas ($564).

**Table 4-4: Descriptive overview of capital expenditure on latrines in Burkina Faso**

| Descriptive statistics | Rural Improved pit latrine | Town Improved pit latrine | Town Ventilated improved pit latrine | All Latrines |
|---|---|---|---|---|
| Count | 152 | 111 | 32 | 295 |
| Min | $0 | $28 | $341 | $0 |
| Max | $181 | $932 | $763 | $932 |
| 1st quartile | $35 | $107 | $508 | $48 |
| **Median** | **$54** | **$176** | **$564** | **$88** |
| 3rd quartile | $75 | $286 | $639 | $232 |
| Mean | $58 | $226 | $543 | $176 |
| StDev | $35 | $169 | $142 | $191 |

This variability is borne out in the Kruskal-Wallis test which shows that capital expenditure varied significantly between the different latrine types ($p<0.05$). Specifically, at the Bonferroni adjusted p-value of 0.017, the cost of improved pit latrines were found to be significantly higher in town areas than rural areas (median $54 vs. $176), in addition the cost of VIP latrines (median $564) were significantly higher than the IPLs in both rural and town areas.

### 4.4.3 Capital expenditure per latrine technology in Ghana

A much smaller sample of 33 latrines were collected in Ghana and across this sample the median capital cost of latrines was $107 (Table 4-5).

**Table 4-5: Descriptive overview of capital expenditure on latrines in Ghana**

| Descriptive statistics | Rural ventilated improved pit latrine | Town traditional pit latrine | Town ventilated improved pit latrine | All latrines |
|---|---|---|---|---|
| Count | 16 | 8 | 9 | 33 |
| Min | $22 | $0 | $27 | $0 |
| Max | $559 | $147 | $536 | $559 |
| 1st quartile | $89 | $58 | $74 | $74 |
| **Median** | **$122** | **$78** | **$111** | **$107** |
| 3rd quartile | $193 | $105 | $148 | $148 |
| Mean | $164 | $71 | $128 | $139 |
| StDev | $161 | $51 | $152 | $142 |

Although median costs varied from a low of $78 for traditional pit latrines in towns to a high of $122 for a VIP in rural areas, the application of the Kruskal Wallis test observed test statistic H (3.62) is not significantly greater than the critical H (5.991) at alpha= 0.05, therefore there is not a significant difference in capital costs between these groupings.

### 4.4.4 Capital expenditure per latrine technology in Mozambique

In Mozambique, 80% of the latrines sampled were traditional pit latrines (TPLs) found in either rural or small town areas. The majority of the households with TPLs were found to construct latrines using materials and labour sourced from within the community, this means that just over a fifth (22%) had incurred a financial cost. In the case of improved pit latrines, 70% of households had incurred some financial costs; however, as mentioned in the introductory section on latrine financing, the financial cost of constructing these latrines may well be under-estimated as the subsidised cost of the domed concrete slab has not been systematically captured. The combination of these factors results in a median cost of latrines sampled of $0, with a maximum of $178 for an IPL in a small town area (Table 4-6).

**Table 4-6: Descriptive overview of capital expenditure on latrines in Mozambique**

| **Descriptive statistics** | **Rural TPL** | **Rural IPL** | **Town TPL** | **Town IPL** | **Town VIP** | **All latrines** |
|---|---|---|---|---|---|---|
| Count | 497 | 35 | 211 | 129 | 12 | 884 |
| Min | $0 | $0 | $0 | $0 | $8 | $0 |
| Max | $22 | $56 | $66 | $178 | $150 | $178 |
| 1st quartile | $0 | $0 | $0 | $0 | $12 | $0 |
| **Median** | **$0** | **$4** | **$0** | **$18** | **$39** | **$0** |
| 3rd quartile | $0 | $12 | $0 | $34 | $75 | $2 |
| Mean | $1 | $9 | $2 | $29 | $48 | $6 |
| StDev | $2 | $14 | $6 | $38 | $47 | $20 |

TPL – Traditional pit latrine; IPL – Improved pit latrine; VIP – Ventilated improved pit latrine

The Kruskal Wallis test applied to these values shows that there is a significant difference between these values ($p<0.05$). Using the Bonferroni adjusted p-value of 0.005 shows that the TPL in rural and town areas are significantly cheaper that the other technology types. The difference between rural IPLs (median $4) and town IPLs (median $18) is not considered significant ($p=0.006$), although given

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the known conservative nature of the Bonferroni correction this may signify a type II error. There was no significant difference between capital expenditure on town IPL and town VIP latrines (p=0.062).

### 4.4.5 Capital expenditure per latrine technology in Sierra Leone

In Sierra Leone all the latrines sampled were located in rural areas with the vast majority classified as either a traditional or improved pit latrine. The median capital expenditure on all latrines was $11 (inter-quartile range $6 to $25). The research methodology in Sierra Leone also quantified the amount of labour (in terms of man days) the household contributed to latrine construction. This time investment was significant – averaging between 6 to 8 man days depending on the latrine type – and representing an average economic cost of $32 per latrine[13]. These economic costs are important signifiers of the level household effort in latrine construction but have not been included as part of the financial cost analysis.

**Table 4-7: Descriptive overview of capital expenditure on latrines in Sierra Leone**

| **Descriptive statistics** | **Rural Traditional pit latrine** | **Rural Improved pit latrine** | **Rural ventilated improved pit latrine** | **All latrines** |
|---|---|---|---|---|
| Count | 105 | 128 | 9 | 242 |
| Min | $0 | $0 | $3 | $0 |
| Max | $158 | $341 | $259 | $341 |
| 1st quartile | $4 | $8 | $7 | $6 |
| **Median** | **$10** | **$14** | **$7** | **$11** |
| 3rd quartile | $16 | $34 | $21 | $25 |
| Mean | $15 | $30 | $35 | $24 |
| StDev | $23 | $47 | $79 | $41 |

The Kruskal Wallis test shows that there is a significant difference between these groupings (p<0.05). Using the Bonferroni adjusted p-value of 0.017 shows that

[13] The economic cost per man day was estimated at 20,000 Leones ($4.6). This estimate was derived from a stakeholder group and is based on the local cost of contracting semi-skilled labour in rural areas. The economic costs incurred by households (in terms of the opportunity costs of time and materials) was not systematically collected across all countries – however the data suggests that in rural areas of Mozambique and Sierra Leone these costs may be considerable.

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IPLs are significantly more expensive than TPLs (median of $14 for IPLS vs. $10 for TPLs). With the small sample size, and high variability of VIP latrine data no significant capital cost differences were found between these and the other technologies.

### 4.4.6 Cross country comparison of capital expenditure

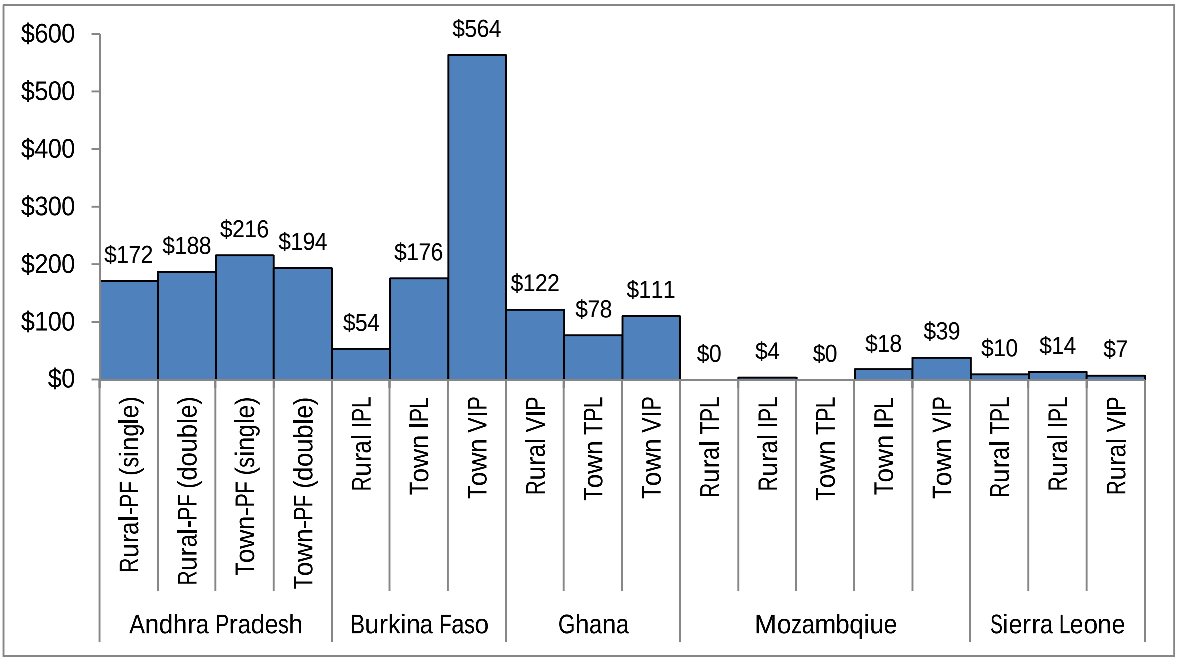
The Kruskal-Wallis test was used to assess the difference in latrine capital expenditure between countries. For this comparison all the data points, for all technologies, were aggregated per country, and analysed (Table 4-8). Costs varied significantly between countries ($p<0.05$). Specifically, at the Bonferroni adjusted p-value of 0.005, the capital expenditure on latrines in Andhra Pradesh (Median $181) was significantly higher than those in Ghana (Median $107), Burkina Faso (Median $88), Sierra Leone (Median $11) and Mozambique (Median $0). There were no significant differences between the capital expenditures in Ghana and Burkina Faso, although both these were significantly more expensive than those in Sierra Leone and Mozambique ($p<0.005$). Latrines in Sierra Leone were significantly more expensive to construct those in Mozambique.

**Table 4-8: Comparison of capital expenditures between five countries**

| Descriptive statistics | Andhra Pradesh | Burkina Faso | Ghana | Mozambique | Sierra Leone |
|---|---|---|---|---|---|
| Count | 2,158 | 295 | 33 | 884 | 242 |
| Min | $0 | $0 | $0 | $0 | $0 |
| Max | $1,707 | $932 | $559 | $178 | $341 |
| 1$^{st}$ quartile | $125 | $48 | $74 | $0 | $6 |
| **Median** | **$181** | **$88** | **$107** | **$0** | **$11** |
| 3$^{rd}$ quartile | $255 | $232 | $148 | $2 | $25 |
| Mean | $211 | $176 | $139 | $6 | $24 |
| StDev | $147 | $191 | $142 | $20 | $41 |

Disaggregating these expenditures per technology shows that the most expensive latrine technology sampled was the improved pit latrine in Burkina Faso (median cost $564). This latrine type was found to be over twice the capital cost of any other latrine sampled in any other county, and significantly more expensive than the other latrines sampled in Burkina Faso (Figure 4-1).The expenditure on the four categories of latrines in Andhra Pradesh are also shown to be consistently higher and less varied than those in the Africa countries.

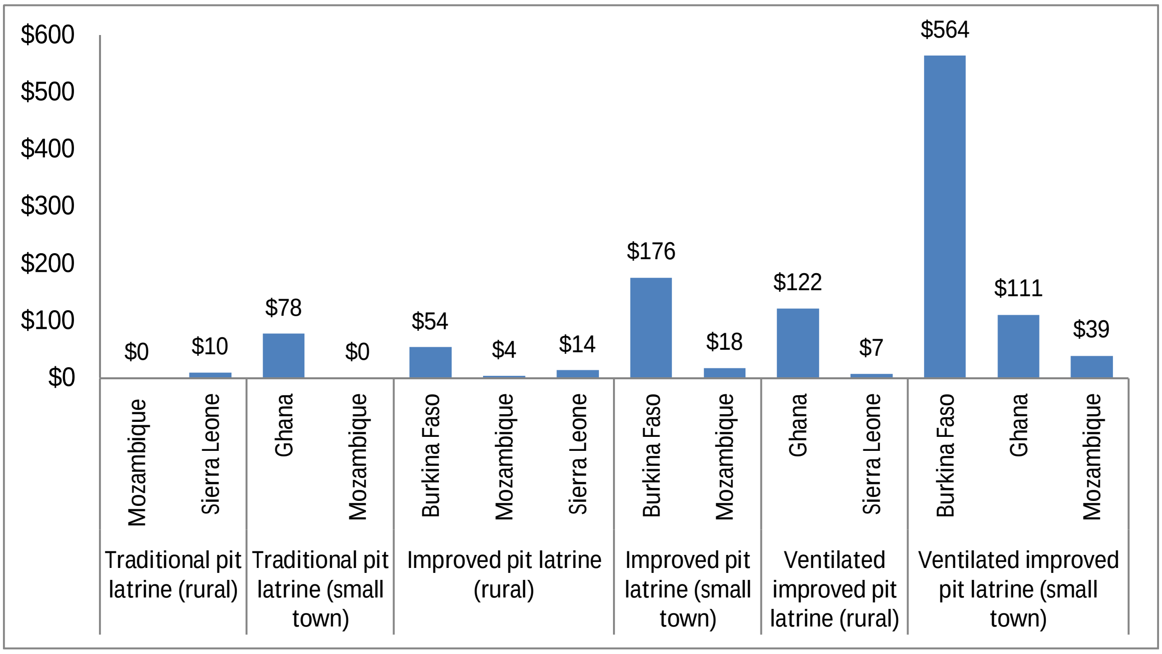
**Figure 4-1: Median capital expenditure on latrines per country**




PF – Pour flush latrine; TPL – Traditional pit latrine; IPL – Improved pit latrine; VIP – Ventilated improved pit latrine

Comparison of the CapEx of *equivalent latrine technologies* is only possible amongst the four African countries where common technologies were identified. Collating these results demonstrates that for each equivalent latrine type, expenditure levels in Burkina Faso and Ghana remain much higher than those in Sierra Leone and Mozambique (Figure 4-2); and typically higher expenditure levels in Burkina Faso than Ghana, although these differences have not been shown to be significant.

**Figure 4-2: Cross-country comparison of median capital expenditure on equivalent latrine technologies**




The most striking aspect of these results is the very large differences in capital construction costs between country contexts and between technologies. Three clear trends appear.

Firstly in Mozambique and Sierra Leone, and particularly in rural areas, many latrines are being constructed by households themselves and little or no financial costs are used on local material and unpaid labour. This is most common for traditional latrines and means expenditures in these countries are well below the other African countries as well as Andhra Pradesh.

Secondly, significant capital expenditure differences have been identified depending on the location of latrines. There are three cases where equivalent latrine technologies were found to have significantly higher capital costs in small town areas compared to rural areas:

- **Andhra Pradesh:** Pour-flush latrine – Single pit (rural $172 vs small town $216)
- **Burkina Faso:** Improved pit latrine (rural $54 vs small town $ 176)
- **Mozambique:** Improved pit latrine (rural $4 vs small town $18)

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In contrast there were no cases where the rural latrines were found to be significantly more costly than their small town equivalent. This suggests that either the robustness of material used for latrine construction, or the cost of the same materials, are greater in small town areas.

Thirdly, within each technology category, within each country, there is considerable variation in the construction costs of latrines. The positive skew of datasets demonstrates that in each case there are a small minority of households spending much more than the median values reported. These variations are more profound amongst the Africa countries. Discussions with country stakeholders - alongside the field experience of the researcher - indicates that for traditional and improved pit latrines, much of the fluctuations in CapEx are caused by substantial variations in the quality of the material used for construction, and different characteristics of the latrine pit (which can vary in depth and lining) material used for the superstructure (reeds, adobe brick, concrete, with or without a roof), and the slab (loose wood, wooden slab, compacted mud, or reinforced concrete).

In contrast, in Andhra Pradesh the widespread state subsidy programme of pour-flush latrines means that latrine construction in general is more formalised and latrines are constructed to defined specifications, and are also heavily influenced by standard ‘unit rates’ by which government pays contractors and/or households. These factors result in expenditure being considerably more uniform in India compared to the African countries.

More generally it can also be seen that with the county studies, the formalised latrine options that conform to the JMP standard of an “improved” latrine namely improved pit latrines, ventilated improved pit latrines and pour flush latrines are shown to be higher cost than traditional pit latrines. These differences are clearly laid out when comparing costs differences between “improved” and “unimproved” latrines (See later section 4.7.1).

## 4.5 Recurrent expenditure

The recurrent costs of latrines are made up of 5 components according WASHCost’s life-cycle costing framework. These unit costs are listed in Table

4-9 alongside an overview on how effectively information on the different elements was collected. In general data on operational expenditures were collected systematically across all countries. Occasional data were collected at household level on expenditures on capital maintenance and were not available in all countries. Additionally indicative data on direct support expenditure were collected in Mozambique and Andhra Pradesh however no data on the costs of capital and expenditure on indirect support were collected. Each recurrent cost component is calculated as a cost per person, per year and all components have been aggregated together for this analysis.

**Table 4-9: The source and availability of recurrent cost data**

| Recurrent cost component | Data sources and availability |
|---|---|
| Operation and minor maintenance expenditure | Data collected from household surveys. A total of 3,613 OpEx data points were collected from across the five countries. |
| Capital maintenance expenditure | Data collected from household surveys. A total of 1,263 CapManEx data points were collected – the majority of these related to data collected in Mozambique and was not systematically available elsewhere. No data capital maintenance values were available in Andhra Pradesh. |
| Expenditure on direct support | Data collected from programmes, local and national government sources. This data could **only** be collected in Andhra Pradesh and Mozambique[14]. |
| Expenditure on indirect support | National government bodies were targeted for this data. However the data collected was piecemeal and could not be attributed to the households sampled. |
| Cost of capital | Some limited costs of capital are likely to exist but have not been systematically captured and remain un-quantified. Households surveys found that are not borrowing money for latrines in Burkina Faso, Mozambique or Sierra Leone. There are some cases where households borrow for sanitation facilities in Andhra Pradesh and it remains uncertain whether they do so or not in Ghana. |

### 4.5.1 Recurrent expenditure on latrines in Andhra Pradesh

The median recurrent expenditure on different latrine technologies varied from \$0.82 to \$1.30 per person, per year. Across all latrines sampled in Andhra Pradesh the median expenditure was \$1.19. Application of the Kruskal Wallis test

[14] Further information on support costs is provided in D.3

showed a significant difference between the four groupings ($p<0.05$). Specifically, recurrent expenditure on double pit flush latrines in towns is significantly lower than the other latrine types at the Bonferroni adjusted p-value of 0.008. This difference is linked to the expenditure on direct support ($0.20) specific to rural areas of Andhra Pradesh. If only household expenditure is taken into account there is no significant difference in recurrent expenditure.

**Table 4-10: Descriptive overview of recurrent expenditure on latrines in Andhra Pradesh**

| **Descriptive statistics** | **Single pit pour flush latrine (Rural)** | **Double pit pour flush latrine (Rural)** | **Single pit pour flush latrine (Town)** | **Double pit pour flush latrine (Town)** | **All latrines** |
|---|---|---|---|---|---|
| Count | 1,770 | 87 | 248 | 47 | 2,152 |
| Min | $0.20 | $0.20 | $0.02 | $0.02 | $0.02 |
| Max | $107.64 | $16.44 | $9.36 | $4.85 | $107.64 |
| 1st quartile | $0.41 | $0.84 | $0.66 | $0.40 | $0.47 |
| **Median** | **$1.22** | **$1.27** | **$1.30** | **$0.82** | **$1.19** |
| 3rd quartile | $2.00 | $2.51 | $2.16 | $1.09 | $2.06 |
| Mean | $1.96 | $2.28 | $1.56 | $0.96 | $1.90 |
| StDev | $5.71 | $2.86 | $1.40 | $1.00 | $5.24 |

### 4.5.2 Recurrent expenditure on latrines in Burkina Faso

In Burkina Faso the majority of values, across all latrine types, falls between $0 and $3 per person per year. In small-town areas, however, a small number of households spend significantly more than this, presumably on occasional pit emptying, with 13% of those with IPL spending more than $17 per person per year and 12% of those with VIPs spending $16 or more.

Overall there is wide variation between the median recurrent expenditures for each technology, these range from $0.66 for improved pit latrines in rural areas to $5.65 for VIPs in small towns (Table 4-11). These differences are significant Bonferroni adjusted p-value of 0.008.

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**Table 4-11: Descriptive overview of recurrent expenditure on latrines in Andhra Pradesh**

| Descriptive statistics | Improved pit latrine (Rural) | Improved pit latrine (Town) | VIP (Town) | All latrines |
|---|---|---|---|---|
| Count | 164 | 141 | 33 | 338 |
| Min | $0.00 | $0.00 | $0.28 | $0.00 |
| Max | $11.24 | $38.54 | $26.61 | $38.54 |
| 1st quartile | $0.13 | $1.52 | $2.20 | $0.55 |
| **Median** | **$0.66** | **$3.74** | **$5.65** | **$1.72** |
| 3rd quartile | $1.79 | $7.48 | $10.32 | $4.57 |
| Mean | $1.26 | $6.47 | $7.27 | $4.04 |
| StDev | $1.59 | $7.88 | $6.42 | $6.20 |

### 4.5.3 Recurrent expenditure on latrines in Ghana

In Ghana, recurrent expenditure values were only available for VIP latrines in rural and town areas, no valid data were collected relating to expenditure on traditional pit latrines. The median expenditure on VIP latrines in town areas ($4.43) is greater than those recorded in rural areas ($2.95), although the small sample of latrines in towns does not allow for meaningful statistical comparison of these values.

**Table 4-12: Descriptive overview of recurrent expenditure on latrines in Ghana**

| Descriptive statistics | Rural ventilated improved pit latrine | Town ventilated improved pit latrine | All Latrine |
|---|---|---|---|
| Count | 42 | 7 | 49 |
| Min | $0.00 | $1.24 | $0.00 |
| Max | $44.29 | $8.86 | $44.29 |
| 1st quartile | $1.11 | $2.29 | $1.11 |
| **Median** | **$2.95** | **$4.43** | **$2.95** |
| 3rd quartile | $6.13 | $6.64 | $6.33 |
| Mean | $6.57 | $4.17 | $6.30 |
| StDev | $9.74 | $2.97 | $9.10 |

### 4.5.4 Recurrent expenditure on latrines in Mozambique

In Mozambique, the level recurrent expenditure by households (i.e. operation and minor maintenance and capital maintenance) is very low. Across all the latrines

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sampled, over 75% of households do not incur any ongoing financial expenditure on maintaining their latrine.

For traditional pit latrines, capital maintenance such as the emptying of the pit does not take place because once full, the latrine is re-sited. As with capital expenditure, any re-siting or pit emptying that does take place is often undertaken by non-paid labour such as family or community members and therefore no financial costs are incurred. The only recurrent expenditure identified is the direct support expenditure made at district level which is broadly targeted at rural sanitation projects and represents a median value of $0.30 per person per year in rural areas. There are no support costs attributed to small town areas.

This direct support expenditure, although small, means that the recurrent expenditure on latrines in rural areas is significantly higher than all of the rural latrines at the Bonferroni adjusted p-value of 0.005. If only household expenditure is accounted for there is no significant difference between any of the latrines sampled.

**Table 4-13: Descriptive overview of recurrent expenditure on latrines in Mozambique**

| **Descriptive statistics** | **Traditional pit Latrine (rural)** | **Improved pit latrine (Rural)** | **Traditional pit Latrine (Town)** | **Improved pit latrine (Town)** | **VIP (Town)** | **All latrines** |
|---|---|---|---|---|---|---|
| Count | 504 | 38 | 222 | 143 | 19 | 927 |
| Min | $0.30 | $0.30 | $0.00 | $0.00 | $0.00 | $0.00 |
| Max | $3.00 | $44.39 | $45.35 | $39.68 | $123.77 | $124 |
| 1st quartile | $0.30 | $0.30 | $0.00 | $0.00 | $0.00 | $0.00 |
| **Median** | **$0.30** | **$0.30** | **$0.00** | **$0.00** | **$0.00** | **$0.00** |
| 3rd quartile | $0.30 | $0.30 | $0.00 | $0.00 | $0.01 | $0 |
| Mean | $0.32 | $1.79 | $0.63 | $1.89 | $6.60 | $1 |
| StDev | $0.20 | $7.14 | $4.40 | $5.96 | $27.60 | $5 |

### 4.5.5 Recurrent expenditure on latrines in Sierra Leone

In Sierra Leone, the median recurrent expenditure across the three types of rural latrines sampled was $0.64 (Table 4-14). The Kruskal Wallis test showed a significant difference between the level of expenditure on the three technologies (p<0.05). Specifically, the median expenditure on traditional pit latrines ($0.22) was significantly less than the median expenditure on improved pit latrines ($0.80) at the Bonferroni adjusted p-value of 0.017. There was no significant difference between the median expenditure on ventilated improved pit latrines ($0.28) and the other technologies, although the sample of these latrines is much smaller.

The vast majority of the recurrent expenditure related to ongoing expenditure on cleaning the latrine, with occasional expenditure recorded for minor repairs to the latrine. The household surveys only recorded 5 cases where latrines had been re-sited or emptied (activities considered a capital maintenance expenditure) but no expenditure values recorded.

**Table 4-14: Descriptive overview of recurrent expenditure on latrines in Sierra Leone**

| **Descriptive statistics** | **Rural Traditional pit latrine** | **Rural Improved pit latrine** | **Rural ventilated improved pit latrine** | **All latrines** |
|---|---|---|---|---|
| Count | 114 | 141 | 10 | 255 |
| Min | $0.00 | $0.00 | $0.06 | $0.00 |
| Max | $12.35 | $20.11 | $1.64 | $20.11 |
| 1st quartile | $0.00 | $0.37 | $0.22 | $0.07 |
| **Median** | **$0.22** | **$0.80** | **$0.28** | $0.64 |
| 3rd quartile | $1.32 | $1.65 | $0.59 | $1.49 |
| Mean | $1.08 | $1.51 | $0.56 | $1.28 |
| StDev | $1.84 | $2.60 | $0.50 | $2.25 |

### 4.5.6 Cross country comparison of recurrent expenditure per person, per year

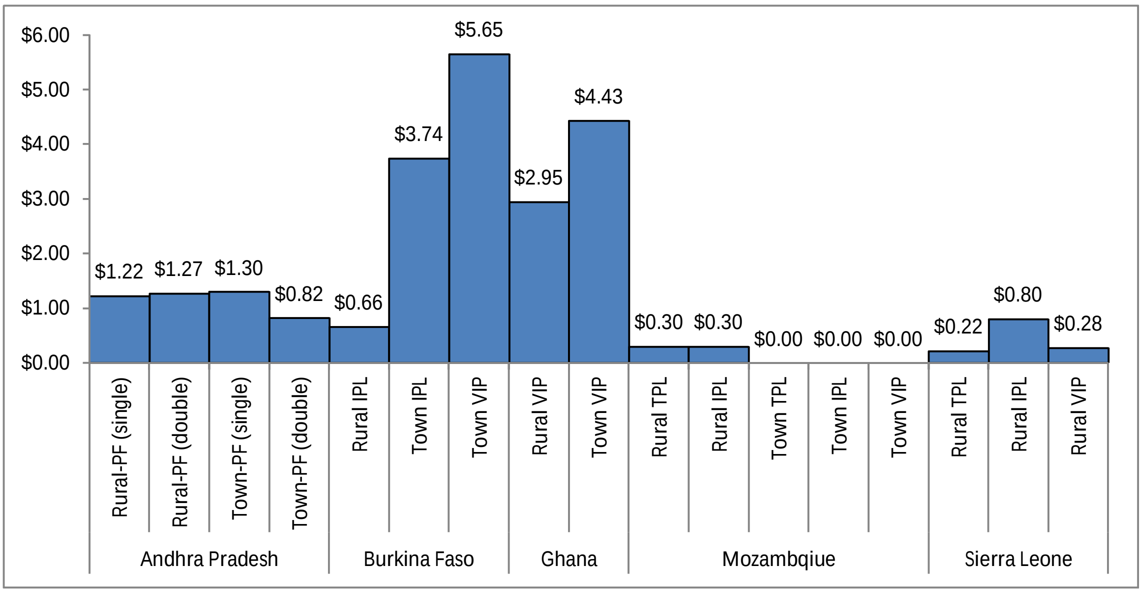
The descriptive data on collated recurrent expenditures for all the latrines in each country are shown in Table 4-15. The Kruskal-Wallis test was used to assess the impact of country type on level of recurrent expenditure on latrines. Costs varied significantly between countries (p<0.05). Specifically, at the Bonferroni adjusted p-value of 0.005, the median recurrent expenditure on latrines in Ghana ($2.95) and Burkina Faso ($1.72) are not significantly different from each other, and are significantly greater than in the other countries. Expenditure on latrines in Andhra Pradesh ($1.19) is significantly greater than in Sierra Leone ($0.64) which is in turn is significantly greater than Mozambique ($0.30).

**Table 4-15: Comparison of recurrent expenditures between five countries**

| **Descriptive statistics** | **Andhra Pradesh** | **Burkina Faso** | **Ghana** | **Mozambique** | **Sierra Leone** |
|---|---|---|---|---|---|
| Count | 2,152 | 338 | 49 | 927 | 255 |
| Min | $0.02 | $0.00 | $0.00 | $0.00 | $0.00 |
| Max | $107.64 | $38.54 | $44.29 | $123.77 | $20.11 |
| 1st quartile | $0.47 | $0.55 | $1.11 | $0.00 | $0.07 |
| **Median** | **$1.19** | **$1.72** | **$2.95** | **$0.30** | **$0.64** |
| 3rd quartile | $2.06 | $4.57 | $6.33 | $0.30 | $1.49 |
| Mean | $1.90 | $4.04 | $6.30 | $0.84 | $1.28 |
| StDev | $5.24 | $6.20 | $9.10 | $5.38 | $2.25 |

A disaggregated comparison of recurrent expenditure per technology is shown in Figure 4-3. These results follow a similar trend to the capital expenditure analysis where the most consistent levels of expenditure across latrine type and location are found in Andhra Pradesh, the highest level of expenditure associated with the ventilated improved pit latrine in Burkina Faso (median expenditure $5.65 per person per year), and the lowest levels of expenditure were found in Mozambique and Sierra Leone. Furthermore in Burkina Faso and Ghana the more advanced VIP latrines are associated with higher levels of recurrent expenditure in comparison to improved pit latrines. These expenditure differences, however, were only found to be significant ($p<0.05$) in Burkina Faso and similar relationship between the type of location of the latrine were not found in the other countries.

**Figure 4-3: Median recurrent expenditure on latrines per country**




PF – Pour flush latrine; TPL – Traditional pit latrine; IPL – Improved pit latrine; VIP – Ventilated improved pit latrine

Importantly it must be considered that these figures do not include expenditure incurred when the pit latrines become full and need emptying. For onsite sanitation there are two options to deal with a full pit: either the pit is abandoned and covered, with a new latrine constructed elsewhere, or it is emptied either manually or by tanker if the pit is lined (Pickford and Shaw, 1997). These costs are considered part of capital maintenance and these were found to occur infrequently across all countries and, in instances where they did occur, little cost information was available that could be attributed to individual latrines. The expected costs of pit emptying are discussed in more detail in section 4.9.3.

## 4.6 Sanitation service levels

Sanitation service levels were defined according to the three indicators of:

- the accessibility of sanitation facilities to the household;
- the use of the household facilities by members of the household, and;
- the reliability of the latrine according to its cleanliness, maintenance, and ease of pit emptying.

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As outlined in methodology section the environmental protection indicator included in the WASHCost sanitation service ladder was considered unreliable and has been excluded from the analysis.

### 4.6.1 Sanitation service levels in Andhra Pradesh

In rural areas of Andhra Pradesh between 65% and 67% of households with a latrine receive a “basic” sanitation service level. This rises to between 71% and 80% in small town areas. One barrier to service delivery is the usage of latrine by household members – with between 7% and 24% of households not using their household level latrine at all – depending on the latrine type. Poor levels of latrine maintenance, particularly in rural areas, mean that over a quarter of rural households (between 27% and 29%) receive a “limited service” for the reliability indicators. In comparison in town areas the ongoing maintenance of latrines is more common and results in the higher percentage of households achieving an overall “basic service” in town areas compared to rural areas.

Overall in Andhra Pradesh there appears to be a good deal of consistency in the level of services achieved by households with either a single or double pour flush pit latrine.

**Table 4-16: Service level per latrine type in Andhra Pradesh state – India**

<table>
<tr><th>Latrine type</th><th>Accessibility</th><th>Use</th><th>Reliability</th><th>Overall service level</th></tr>
<tr><td rowspan="3">Single pit pour flush latrine (rural)</td><td rowspan="3">100% Improved service</td><td>30% Improved service</td><td rowspan="2">73% Basic service</td><td>65% Basic service</td></tr>
<tr><td>52% Basic service</td><td>18% Limited service</td></tr>
<tr><td>17% No service</td><td>27% Limited service</td><td>17% No service</td></tr>
<tr><td rowspan="3">Double pit pour flush latrine (rural)</td><td rowspan="2">98% Improved service</td><td>33% Improved service</td><td rowspan="2">71% Basic service</td><td>67% Basic service</td></tr>
<tr><td>59% Basic service</td><td>24% Limited service</td></tr>
<tr><td>2% Limited service</td><td>9% No service</td><td>29% Limited service</td><td>9% No service</td></tr>
</table>

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<table>
<tr><td rowspan="3">Single pit pour flush latrine (Town)</td><td rowspan="3">100% Improved service</td><td>26% Improved service</td><td rowspan="2">83% Basic service</td><td>80% Basic service</td></tr>
<tr><td>68% Basic service</td><td>13% Limited service</td></tr>
<tr><td>7% No service</td><td>17% Limited service</td><td>7% No service</td></tr>
<tr><td rowspan="3">Double pit pour flush latrine (Town)</td><td rowspan="3">100% Improved service</td><td>6% Improved service</td><td rowspan="2">84% Basic service</td><td>71% Basic service</td></tr>
<tr><td>71% Basic service</td><td>6% Limited service</td></tr>
<tr><td>24% No service</td><td>16% Limited service</td><td>24% No service</td></tr>
</table>

### 4.6.2 Sanitation service levels in Burkina Faso

In Burkina Faso between 35% and 64% percent of households accessing a latrine receive a “basic” sanitation service. The lowest levels of service were found in rural areas where 30% of the sampled improved pit latrines are not consistently used and 41% were found to be poorly maintained. The combination of these factors means that nearly two-thirds (64%) of rural IPLs are classified as providing “no service”. The issue of latrine use was also prevalent in small town areas, 50% of households with a VIP latrine and 44% with an improved pit latrine were not found to be using their latrines adequately. Issues of pit emptying and latrine cleanliness were much less frequent in small towns compared to rural areas meaning that between 15% and 20% more of the households receive a “basic” overall service in rural areas.

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**Table 4-17: Service level per latrine type in Burkina Faso**

<table>
<tr><th>Latrine Type</th><th>Accessibility</th><th>Use</th><th>Reliability</th><th>Overall service level</th></tr>
<tr><td rowspan="3">Improved pit latrine (rural)</td><td rowspan="2">65% Improved service</td><td>21% Improved service</td><td>10% Improved service</td><td>1% Improved service</td></tr>
<tr><td>49% Basic service</td><td>49% Basic service</td><td>35% Basic service</td></tr>
<tr><td>35% Basic</td><td>30% No / limited service</td><td>41% No service</td><td>64% No / limited service</td></tr>
<tr><td rowspan="3">Improved pit latrine (Town)</td><td rowspan="2">86% Improved service</td><td>18% Improved service</td><td>20% Improved service</td><td rowspan="2">54% Basic service</td></tr>
<tr><td>38% Basic service</td><td>75% Basic service</td></tr>
<tr><td>14% Basic</td><td>44% No / limited service</td><td>6% No service</td><td>46% No / limited service</td></tr>
<tr><td rowspan="3">VIP latrine (Town)</td><td rowspan="2">87% Improved service</td><td>17% Improved service</td><td rowspan="2">93% Basic service</td><td rowspan="2">50% Basic service</td></tr>
<tr><td>33% Basic service</td></tr>
<tr><td>13% Basic</td><td>50% No / limited service</td><td>7% No service</td><td>50% No / limited service</td></tr>
</table>

### 4.6.3 Sanitation service levels in Ghana

In the relatively small data sample collected in Ghana, there is a stark contrast between the service levels achieved for traditional pit latrines and ventilated improved pit latrines. Due to the absence of a safe impermeable slab, all the traditional latrines are classified as providing a “limited service” in terms of the access indicator. However in addition, 80% of TPLs in rural areas and 92% in small town areas are not cleaned regularly and found to be extremely dirty leading to “no service” for the reliability indicator. Ventilated improved pit latrines in rural and small town areas were found to be better maintained leading to a much greater percentage of households (between 71% and 86%) of households achieving a “basic” sanitation service.

**Table 4-18: Service level per latrine type in Ghana**

<table>
<tr><th>Latrine Type</th><th>Accessibility</th><th>Use</th><th>Reliability</th><th>Overall service level</th></tr>
<tr><td rowspan="2">Traditional pit latrine (Rural)</td><td rowspan="2">100% Limited service</td><td>92% Improved service</td><td>24% Basic service</td><td>20% Limited service</td></tr>
<tr><td>8% No service</td><td>76% No service</td><td>80% No service</td></tr>
<tr><td rowspan="3">VIP latrine (Rural)</td><td rowspan="2">87% Improved service</td><td>80% Improved service</td><td rowspan="2">71% Basic service</td><td rowspan="2">71% Basic service</td></tr>
<tr><td>15% Basic service</td></tr>
<tr><td>13% Basic service</td><td>5% No service</td><td>29% No service</td><td>29% No service</td></tr>
<tr><td rowspan="3">Traditional pit latrine (Town)</td><td rowspan="3">100% Limited service</td><td rowspan="3">100% Improved service</td><td rowspan="2">8% Basic service</td><td>8% Limited service</td></tr>
<tr><td rowspan="2">92% No service</td></tr>
<tr><td>92% No service</td></tr>
<tr><td rowspan="3">VIP latrine (Town)</td><td rowspan="2">98% Improved service</td><td>93% Improved service</td><td>8% Improved service</td><td rowspan="2">86% Basic service</td></tr>
<tr><td>2% Basic service</td><td>81% Basic service</td></tr>
<tr><td>2% Basic service</td><td>5% No service</td><td>11% No service</td><td>14% No service</td></tr>
</table>

### 4.6.4 Sanitation service levels in Mozambique

The indicators collected in Mozambique show that for improved pit latrines and ventilated improved pit latrines over 97% of households are receiving a “basic” service. As the traditional pit latrines do not have an impermeable slab they are classified as having a “limited service” in terms of access. The level of latrine use recorded in Mozambique is markedly higher than in other countries but this difference is likely to be in part due to variations in how the use indicator was collected and recorded by enumerators in each country[15] and these values should be treated with some caution.

[15] In Mozambique, the exact number of family members using the latrine was not established during the household survey. Therefore if the latrine was used by the household respondent then a “basic” level was given without taking into account other household members. In the other countries this information about the number of users per latrine

**Table 4-19: Service level per latrine type in Mozambique**

| Latrine Type | Accessibility | Use | Reliability | Overall service level |
|---|---|---|---|---|
| Traditional pit latrine (Rural) | 100% Limited service | 99% Basic service | 98% Basic service | 97% Limited service |
| | | 1% No service | 2% No service | 3% No service |
| Improved pit latrine (Rural) | 92% Improved service | 100% Basic service | 97% Basic service | 97% Basic service |
| | 8% Basic service | | 3% No service | 3% No service |
| Traditional pit latrine (Town) | 100% Limited service | 95% Basic service | 4% Improved service | 87% Limited service |
| | | | 87% Basic service | |
| | | 5% No service | 10% No service | 13% No service |
| Improved pit latrine (Town) | 95% Improved service | 100% Basic service | 30% Improved service | 99% Basic service |
| | | | 68% Basic service | |
| | 5% Basic service | | 1% No service | 1% No service |
| VIP latrine (Town) | 100% Improved service | 100% Basic service | 42% Improved service | 100% Basic service |
| | | | 58% Basic service | |

### 4.6.5 Sanitation service levels in Sierra Leone

In rural Sierra Leone there were two main barriers to achieving a "basic" level of service related to the indictors of access and reliability. For the traditional pit latrines the main threat to service access relates to the separation of users from faecal waste. When there is no contiguous slab, users do not have a stable platform to stand on and there is no effective user-faeces separation. Many of these slabs were wooden slabs (usually covered with mud or soil) and consequently maintain a potential risk of unpredictable collapse from termite/ants decay and also present a higher risk of helminth transmission (Baker and Ensink,

was collected and if only some family members use the latrine a "limited" service was given – this nuance is not possible in Mozambique and likely contributes the comparatively higher "basic" service values recorded under the use indicator.

2012). These are therefore classified as a “limited” service in terms of accessibility.

An additional issue and one common to all latrines technologies that were sampled in Sierra Leone, is that of the cleanliness and safety of household latrines. Enumerators observed that many latrines were extremely dirty and filled with flies – corresponding therefore to a high percentage of “limited” and “no service” values in terms of the reliability indicator. This issue was most pronounced for traditional pit latrines where 62% of latrines were dirty and infested with flies, compared to 26% of improved pit latrines and 47% of ventilated improved pit latrines. These factors mean that for any latrine type less than 10% of households were considered to be receiving a basic overall sanitation service

**Table 4-20: Service level per latrine type in Sierra Leone**

<table>
<tr><th>Latrine Type</th><th>Accessibility</th><th>Use</th><th>Reliability</th><th>Overall service level</th></tr>
<tr><td rowspan="3">Traditional pit latrine (Rural)</td><td>1% Improved service</td><td rowspan="2">54% Improved service</td><td>3% Basic service</td><td>37% Limited service</td></tr>
<tr><td>7% Basic service</td><td>35% Limited service</td><td rowspan="2">62% No service</td></tr>
<tr><td>92% Limited service</td><td>46% Basic service</td><td>62% No service</td></tr>
<tr><td rowspan="3">Improved pit latrine (Rural)</td><td>71% Improved service</td><td rowspan="2">46% Improved service</td><td>9% Basic service</td><td>9% Basic service</td></tr>
<tr><td>28% Basic service</td><td>64% Limited service</td><td>64% Limited service</td></tr>
<tr><td>1% Limited service</td><td>54% Basic service</td><td>26% No service</td><td>26% No service</td></tr>
<tr><td rowspan="3">VIP latrine (Rural)</td><td>25% Improved service</td><td rowspan="2">55% Improved service</td><td>4% Basic service</td><td>4% Basic service</td></tr>
<tr><td>69% Basic service</td><td>49% Limited service</td><td>49% Limited service</td></tr>
<tr><td>5% Limited service</td><td>45% Basic service</td><td>47% No service</td><td>47% No service</td></tr>
</table>

## 4.7 Expenditure and service level comparison

This sub-section compares the median capital expenditure and recurrent expenditure on household latrines with the service levels achieved. These values have been calculated per country and the comparisons are shown in Figure 4-4 and Figure 4-5.

The countries with the highest median capital expenditure on latrines (Andhra Pradesh (India) and Ghana) also recorded the highest percentage of users receiving a "basic" level of service (66% and 62% respectively). Conversely the countries with the lowest levels of capital expenditure, Mozambique and Sierra Leone, recorded the lowest percentage of users with a "basic" service (29% and 5% respectively).

Broadly similar findings are found when comparing recurrent expenditure with service levels achieved. The highest median recurrent expenditure values were associated with the ventilated improved pit latrine sampled in Ghana (median expenditure $2.95 per person per year) and this technology also achieved the highest percent of households achieving a "basic service" (75%) [16]. Conversely, in Sierra Leone median recurrent expenditure of $0.64 per person year – the second lowest of the five countries – corresponded to just 5% of households achieving a "basic service". However this pattern in not replicated throughout as median expenditure was a third higher in Burkina Faso in comparison to Andhra Pradesh, yet 27% less households achieved a basic service. Moreover in Mozambique despite a median of $0.00 being spent on after constructing the latrine, 25% more households achieved a basic service in comparison to Sierra Leone.

[16] Note: The cost and service level data for Ghana in Figure 4-4 solely refers to VIP latrine data as no cost data was forthcoming on traditional pit latrines and these have therefore been excluded from the comparison.

**Figure 4-4: Sanitation service levels per county against capital expenditure per latrine**

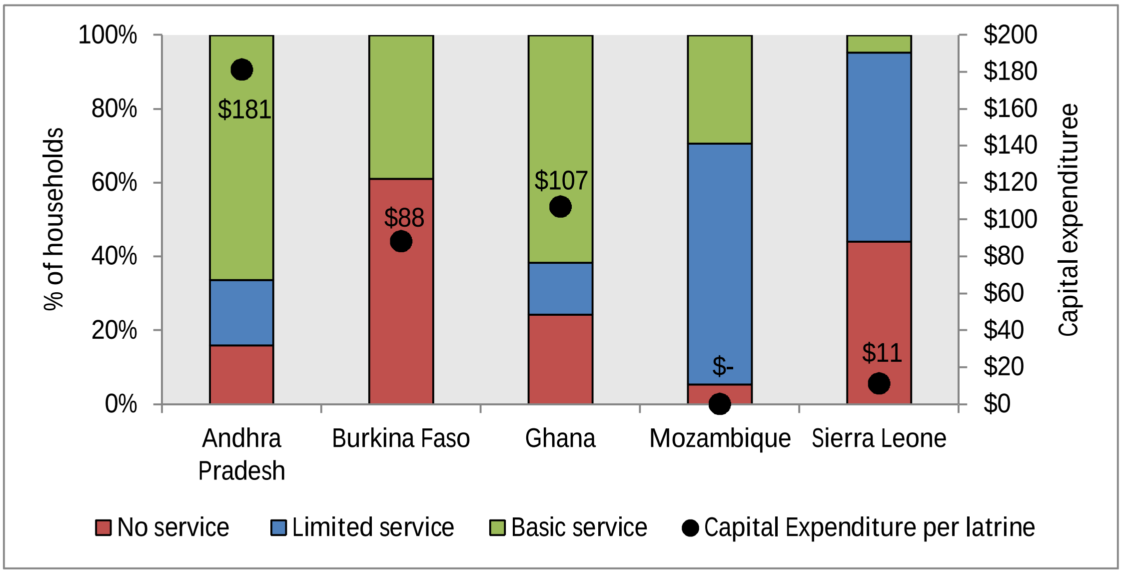
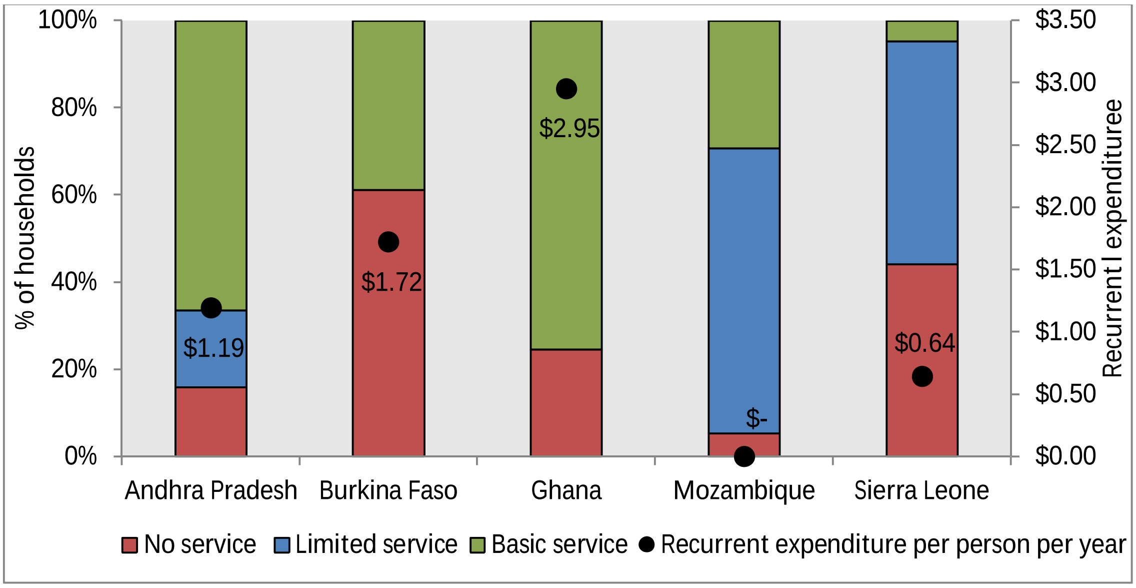



**Figure 4-5: Sanitation service levels per county against recurrent expenditure per person, per year**




The five country service level analyses show that the most prevalent factor inhibiting the delivery of “basic” service is the “reliability” of the latrine defined in terms of how the latrine is maintained, cleaned and emptied (see Table 3-7 for more details on how this indicator was calculated in each country). In three countries: Andhra Pradesh (India), Burkina Faso, and Sierra Leone, over a third of households had latrines that were extremely dirty and were therefore burdened with associated problems of the infestation of flies, and strong odours (Table 4-21). The anomaly in this analysis is Mozambique where only 4% of latrines were considered extremely dirty – well below any of the other countries. One likely explanation is that in Mozambique the indicator was entirely based on enumerator observations of latrine cleanliness which are inherently subjective to the enumerator and the context.

**Table 4-21: Reliability of latrines in each study area**

| Country | Percentage of households with "no service" for reliability |
|---|---|
| Andhra Pradesh | 36% |
| Burkina Faso | 33% |
| Ghana | 20% |
| Mozambique | 4% |
| Sierra Leone | 44% |

One other notable problem was that of latrine use particularly in Andhra Pradesh and Burkina Faso. In Burkina Faso nearly one third (32%) were found to be unused compared with 16% of latrines which were not used by any family member in Andhra Pradesh.

### 4.7.1 Comparison of "improved" and "unimproved" latrines

At present the WASH sector progress at global and national levels towards the millennium development goals for sanitation is measured according to the number of households being served by "improved" latrines, defined as a household latrine that "hygienically separates human excreta from human contact" (WHO/UNICEF, 2012). In relation to the WASHCost service ladder the improved/unimproved dichotomy corresponds to the sanitation access indicator – where latrines without hygienic separation were classified as providing a "limited service".

This sub-section compares the costs of service levels found for latrines re-classified as either "improved" or "unimproved" according to this global standard. The results show that the level of capital and recurrent expenditure on improved latrines is considerably higher than on unimproved latrines (Figure 4-6 and

Figure 4-7). The median financial cost of constructing an improved latrine is $154 in rural areas and $179 in small towns. This compares with a median expenditure of $0.00 for unimproved latrines that were commonly found to be constructed by households themselves, using local materials. Similarly analysis of median recurrent expenditure shows that households rarely spend anything on operating and maintain unimproved latrines. In comparison the expenditure on improved latrines is considerably higher at a median of $1.17 per person per year in rural areas and a median of $1.14 per person per year in small towns.

Higher capital and recurrent expenditure on improved latrines coincides with higher levels of “basic services” being achieved. In small town areas 83% of improved latrines achieved a “basic” level of service compared to 55% in rural areas. In comparison none of the unimproved latrines sampled achieved a “basic” level of service. Unimproved latrines are found to have lower service levels across all WASHCost service ladder indicators and are more likely to be unused, unclean and in a poor state of repair, in comparison to improved technologies.

**Figure 4-6: Level of sanitation service achieved for improved and unimproved latrines compared with capital expenditure per latrine**

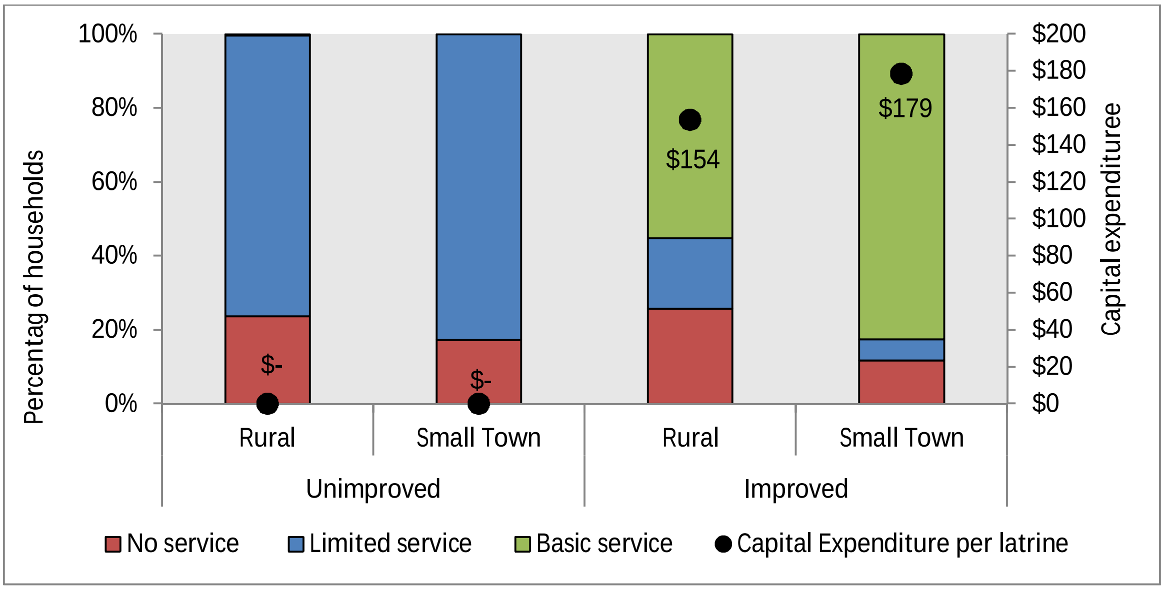
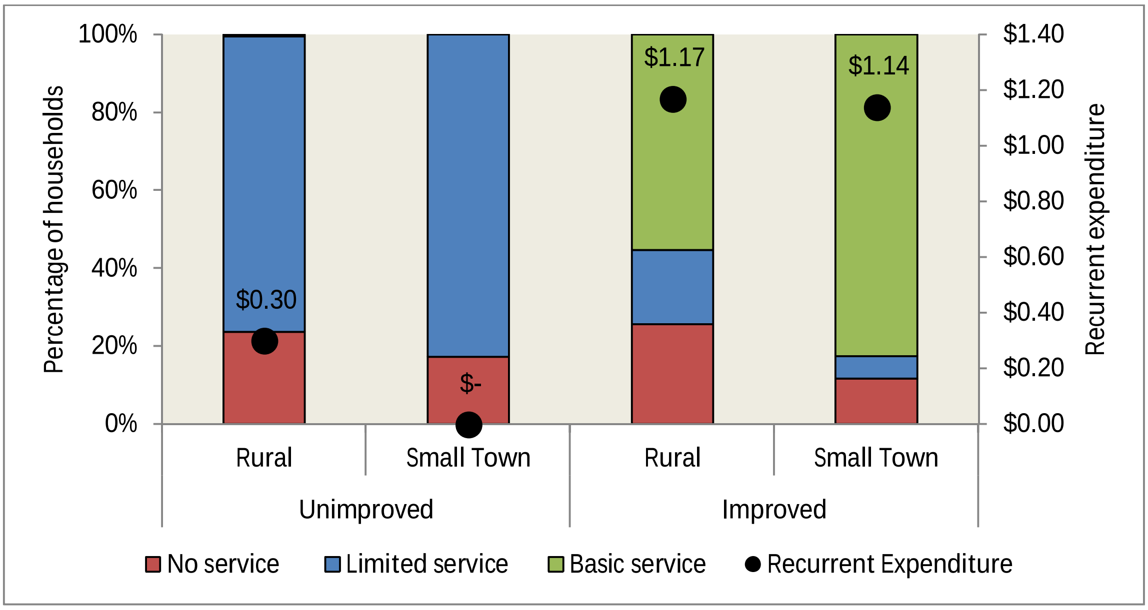


**Figure 4-7: Level of sanitation service achieved for improved and unimproved latrines compared with recurrent expenditure per person per year**




## 4.8 Summary and implications

A key part of research objective 1 was to report on the levels of capital and recurrent expenditure across the five countries – for clarity these are presented in Table 4-22 and Table 4-23.

Table 4-22Table 4-22 and Table 4-23.

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**Table 4-22: Median latrine capital expenditure**

| Country | Latrine type | JMP status | Median capital expenditure | | Range of median expenditure |
|---|---|---|---|---|---|
| | | | **Rural** | **Small town** | |
| Andhra Pradesh | Single pit pour flush latrine | Improved | $172 | $216 | $172-$216 |
| | Double pit pour flush latrine | Improved | $188 | $194 | |
| Burkina Faso | Improved pit latrine | Improved | $54 | $176 | $54-$564 |
| | VIP latrine | Improved | - | $564 | |
| Ghana | Traditional pit latrine | Unimproved | - | $78 | $78-$122 |
| | VIP latrine | Improved | $122 | $111 | |
| Mozambique | Traditional pit latrine | Unimproved | $0 | $0 | $0-$39 |
| | Improved pit latrine | Improved | $4 | $18 | |
| | VIP latrine | Improved | - | $39 | |
| Sierra Leone | Traditional pit latrine | Unimproved | $10 | - | $7-$14 |
| | Improved pit latrine | Improved | $14 | - | |
| | VIP latrine | Improved | $7 | - | |
| Range all unimproved latrine | | $0-$39 | | | |
| Range all improved latrine: Andhra Pradesh, Burkina Faso, Ghana | | $54 - $564 | | | |
| Range all improved latrines: Mozambique, Sierra Leone | | $4-$39 | | | |

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**Table 4-23: Median latrine recurrent expenditure**

| Country | Latrine type | JMP status | Median recurrent expenditure | | Range of recurrent expenditure |
|---|---|---|---|---|---|
| | | | **Rural** | **Small town** | |
| Andhra Pradesh | Single pit pour flush latrine | Improved | $1.22 | $1.30 | $0.82-$1.30 |
| | Double pit pour flush latrine | Improved | $1.27 | $0.82 | |
| Burkina Faso | Improved pit latrine | Improved | $0.66 | $3.74 | $0.66-$5.65 |
| | VIP latrine | Improved | - | $5.65 | |
| Ghana | Traditional pit latrine | Unimproved | - | | $2.95-$4.43 |
| | VIP latrine | Improved | $2.95 | $4.43 | |
| Mozambique | Traditional pit latrine | Unimproved | $0.30 | $0.00 | $0.00-$0.30 |
| | Improved pit latrine | Improved | $0.30 | $0.00 | |
| | VIP latrine | Improved | - | $0.00 | |
| Sierra Leone | Traditional pit latrine | Unimproved | $0.22 | - | $0.22-$80 |
| | Improved pit latrine | Improved | $0.80 | - | |
| | VIP latrine | Improved | $0.28 | - | |
| Range all unimproved latrine | | $0.22-$0.30 | | | |
| Range all improved latrine: Andhra Pradesh, Burkina Faso, Ghana | | $0.66-$5.65 | | | |
| Range all improved latrine: Mozambique, Sierra Leone | | $0.00-$0.80 | | | |

These findings demonstrate that the costs of constructing and maintaining latrines vary significantly between countries, between technologies, and between rural and small town areas.

At the aggregate level, latrines in Andhra Pradesh are significantly more expensive to construct than any of the African countries. These are formalised pour-flush latrines, many of which have been partially subsidised by the state government and all of which have been promoted for many years as part of the national sanitation campaign.

Amongst the African countries, the latrines in Sierra Leone and Mozambique are being constructed at significantly lower costs than the other countries, mainly because labour and materials are being sourced locally at no-monetary cost.

This approach presents its own opportunities and challenges. The fact that these latrines can be constructed by households with little or no external existence means that these systems can play a key role in increasing first time access to sanitation in lower-income countries. However, the vast majority of these latrines households are rudimentary traditional pit latrines which are not providing safe separation of users and waste. In both cases these do not meet either the WASHCost “basic” service level or the JMP “improved” standard.

In Andhra Pradesh, Burkina Faso, and Ghana households are spending significant amounts (often considerably more than $100 per latrine) on a variety of “improved” latrine technologies. In Sierra Leone the vast majority of ‘improved’ latrines were found to be extremely dirty and infested with flies, and despite providing adequate faecal separation, are not providing a “basic service” by the definitions agreed for this research (though there may well be some level of ‘international bias’ built in to this judgement, as evidenced by the different view of Mozambican field researchers). Additional data collected in Sierra Leone demonstrated that there is a great deal of variability in the construction quality and characteristics of latrines nominally classified as the same technology. This data showed that to construct a robust pit latrine with an effective impermeable slab (most commonly concrete) that users will continue to use costs approximately $40, more than double the cost of latrines not achieving this service level (see Box 1). Ventilated improved pit latrines delivering a “basic service” in Mozambique are found to cost a similar amount ($39 per latrine).

Across all latrines the two main factors limiting the overall sanitation service delivered to households are the use and reliability of household latrines.

The inadequate use of household latrines was found to be a particular problem in Andhra Pradesh and Burkina Faso and demonstrates the fragility of demand for sanitation facilities. The reasons for this slippage in latrine usage were not assessed. However it is likely that part of the reason, as also identified by Ross et al., (2011) in Ethiopia, was latrine usage is sustained only until the point when the pit became full and then households would not empty or re-site the latrine and so revert back to traditional practices. The consequences of not emptying pit latrines can impact service delivery and health outcomes. Full, or overflowing pits, pose an environmental risk and can contaminate local water sources and public areas (Yoke Pean et al., 2011).

Examples of pit emptying – and associated expenditure data – were rarely encountered in this study indicating that current levels are insufficient. An assessment of the required ("normative") expenditure on these activities is given in the following section.

## 4.9 Normative expenditure to sustain sanitation systems

### 4.9.1 Capital expenditure

The large sample size in Andhra Pradesh provides a robust capital expenditure estimate of $181 per latrine (inter-quartile range $125-$255), though one that is heavily influenced by standard 'unit rates' by which government pays contractors and/or households) for improved latrines that meet national guidelines. The construction cost of an improved latrine in Ghana, and Burkina Faso is found to be approximately $100 for an improved latrine (although values vary considerably), and a minimum capital expenditure of $40 in Sierra Leone and Mozambique.

### 4.9.2 Operational and minor maintenance expenditure

At the aggregate level there is no clear relationship between expenditure on OpEx and subsequent latrine cleanliness between countries. This is perhaps unsurprising as the physical work to keep latrines in a hygienic state can be done largely without monetary expenditure. The only expenditure that you would expect to see would be on cleaning material such as soap and detergents. The detailed country study in Sierra Leone (details in Box 1 below), did find that the small number of households that were achieving a basic service were spending an average of $2.4 per person per year on soap and detergents and $0.3 per person per year on latrine repairs ($2.7 per person, per year in total), conversely households spending less than a mean $0.5 per person per year on soap were to have extremely dirty, and fly infested latrines.

### 4.9.3 Capital maintenance expenditure (pit emptying/latrine re-siting)

The required capital maintenance for pit latrines will depend on two factors:

- The cost of latrine emptying or re-siting
- The frequency that pit emptying is required

In rural and small town areas the most common pit emptying options are; manual emptying, emptying by tanker or manual pump (only if the pit is lined), or the abandonment and re-siting of latrines (Still, 2002).

The length of time it takes a pit to fill is contingent on various factors. Pickford (2005) identifies the number of users, size of pit, soil characteristics and the material used for anal cleansing, with Franceys, Pickford and Reed (1992) suggesting that accumulation rates will be approximately 33% slower in wet conditions over dry conditions. The variability in these factors means that it can take different periods before the pit is full and capital maintenance is required, as discussed by Still (2002) who states that interval could range between 3 and 20 years.

In this research the only primary data collected relates to a small sample of data relating to pit-emptying costs in Mozambique. The results showed that the cost of manual pit emptying between different latrine types was similar, ranging from $14.3 to $14.7 – mean $15.1. The time taken before the pit became full varied from 3.5 to 4.6 years (mean 4.4 years). In town areas there is a higher likihood that mechanical pit emptying services will be availiable and used by households. No primary data was avaialble on these expenditures, secondary values for these services are derived from a study of global mechanical empying costs in urban areas $48 a year in Asian cities and $134 a year in Africa cities.

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Calculated indicative values for normative CapManEx are shown in Table 4-24. Costs range between $0.80 and $1.60 per person per year for mechanical services in Andhra Pradesh and $0.60 and $5.00 per person per year for either manual or mechanical services in the African countries. The cost of emptying services and the frequency of pit emptying are likely to vary considerably between contexts and therefore these results should be treated with some caution.

**Table 4-24: The number of years before latrines became full in Mozambique**

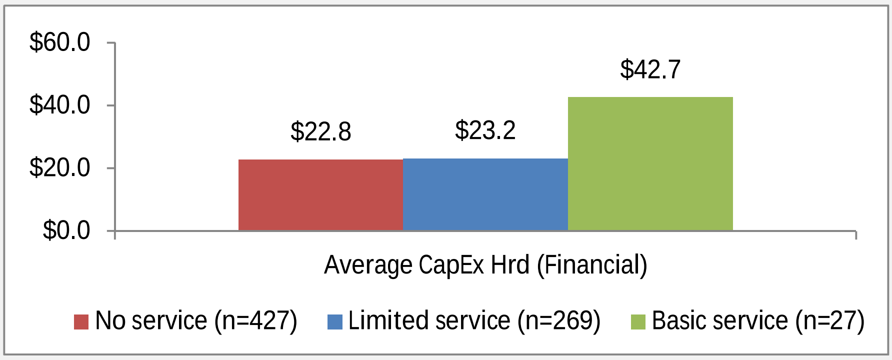
| Country | Latrine type | Means of pit emptying | Frequency of pit emptying (years) | Assumed cost of pit emptying | Normative CapManEx per person, per year |
|---|---|---|---|---|---|
| Andhra Pradesh | Pour flush (single pit) | Mechanical | 5*** | $48.00 | $1.60 |
| | Pour flush (double pit) | | 10*** | | $0.80 |
| African countries | Improved pit latrine or VIP latrine | Manual | 4.5 | $15.10 | $0.60 |
| African countries | Improved pit latrine or VIP latrine | Mechanical | 4.5 | $134.00 | $5.00 |

* Assumption based on WASHCost data; **Assumption based on Chowdhry and Kone (2012);***Assumed values based on WASHCost India research team

**Box 1: Indicative "ideal" expenditure analysis in Sierra Leone**

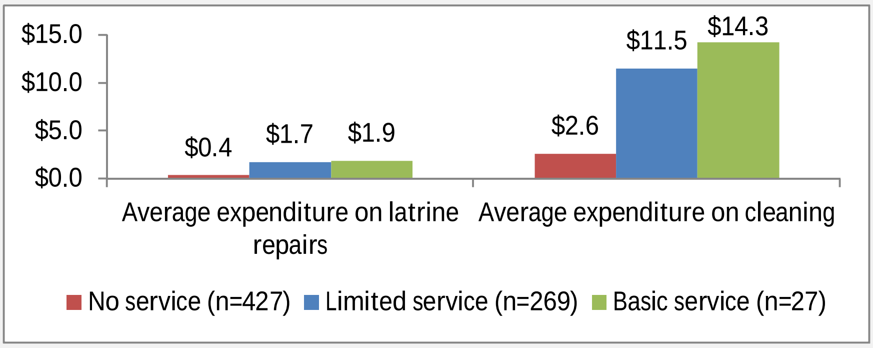
Households achieving a basic service spent around twice the financial capital expenditure on their latrine than those that achieved limited or no service ($43 compared to $22). Consequently in the Sierra Leone context a threshold may exist at around $40 per latrine facility (i.e. $ 8.3 per person) that represents what is required to construct a robust pit latrine with an effective impermeable slab (concrete slab), that users will continue to use.

**Figure 4-8: Capital expenditure per sanitation service level**




Other key elements of sanitation service delivery are correlated with expenditure on minor repairs and keeping the latrine clean and hygienic. Household's achieving a basic level of service spend the most on operating expenditure, and conversely those achieving "no service" are correlated with the lowest expenditure levels. Combining these two expenditure values together yields a tentative guideline operational expenditure for a basic service of $ 16.2 per year ($ 2.7 per person per year).

**Figure 4-9: Operational expenditure per sanitation service level**



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# 5 Rural and small town water supply costs

## 5.1 Introduction

This Chapter provides empirical findings on: a) the amount that has been spent to construct and maintain different types of water supply systems across five lower-income countries: India (Andhra Pradesh state), Burkina Faso, Ghana, Mozambique, and Sierra Leone; and b) the corresponding levels of "water service[17]" different types of water supply systems are delivering to households in the different country contexts.

Initially this chapter presents the data for each country, before assessing the level of expenditure between countries. These findings relate directly to the first research objective, namely: to increase the level of knowledge in the sector about how much is being spent to deliver water services in lower-income countries. The final section of this chapter assesses whether existing expenditure is sufficient to attain service delivery goals (sub-objective 1.3) and, in doing so, it provides a set of indicative values on the levels of unit cost expenditure required (sub-objective 2.1).

For coherence the costs of each supply technology presented in both the individual country studies and the cross-country analysis are given as the arithmetic mean of the systems sampled, with inter-quartile ranges and chosen descriptive statistics cited as appropriate. A descriptive overview of the institutional arrangements determining how water systems are managed and financed in each country is found in Appendix E.1 as well as the details of the data sample collected in each country.

## 5.2 Andhra Pradesh

### 5.2.1 Capital expenditure on water systems

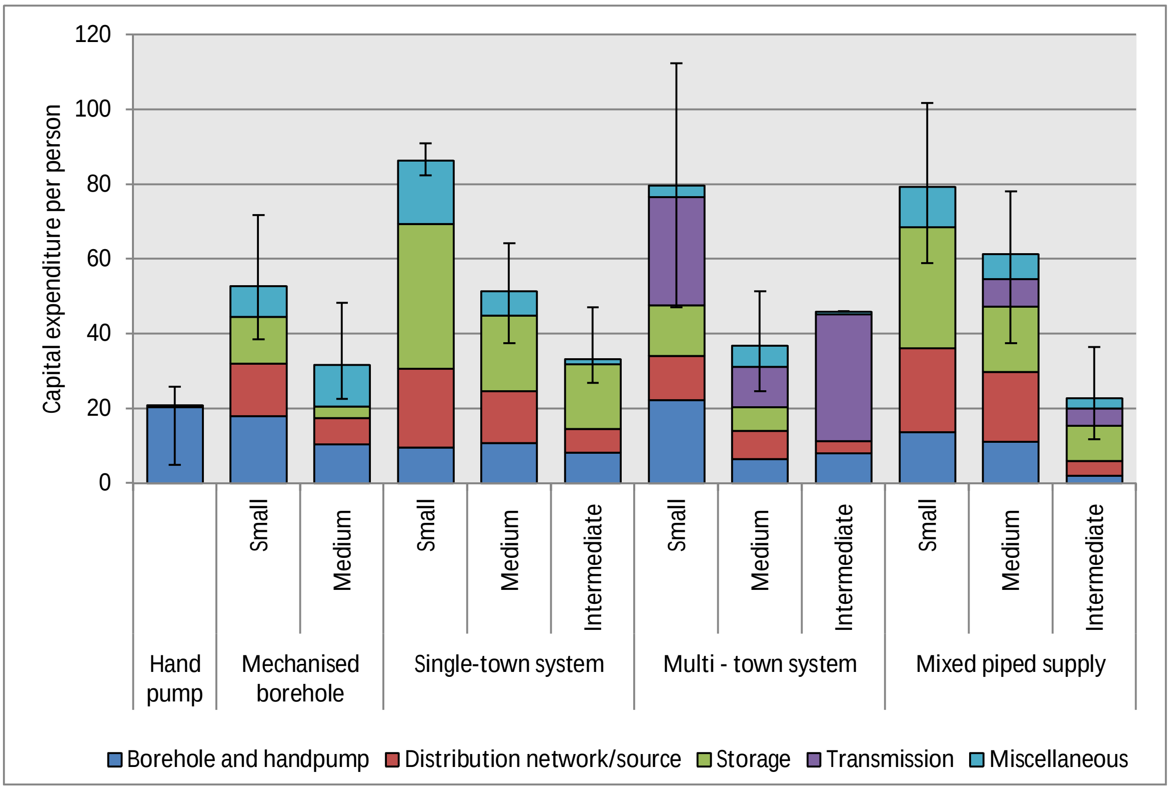
In Andhra Pradesh the mean capital expenditure for different piped systems varies from a low of $22 per person for an intermediate-size mixed piped supply

[17] According to the WASHCost water service levels

network to a high of $87 per person for a small single-town system (Figure 5-1 and Table 5-1). Across the systems sampled there is clear evidence of economies of scale where the cost of constructing the larger intermediate sized systems (5,000+ users) tends to be between two to three times cheaper per person than small systems (<500 users).

For piped systems of comparable sizes the least cost technology appears to be the mechanised borehole systems (small system $52 per person, medium sized system $32 per person), which are approximately a third or half the cost of similarly sized single-town, multi-town and mixed piped systems respectively. The cheapest water supply option in Andhra Pradesh state was found to be the borehole and handpump systems at $21 per person.

Figure 5-1: Mean government capital expenditure per person in Andhra Pradesh (with interquartile ranges[18]).




[18] The interquartile range bars have been placed on the bars in Figure 5-1 However, due to the variations in the number of systems sampled for different service delivery models, these bars do not indicate the statistically significant

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**Table 5-1: Capital expenditure per person per technology in Andhra Pradesh – with minimum, maximum and inter-quartile ranges**

| Service delivery model | Service area size | Nº of service areas | Min | Max | Inter-quartile range | Mean |
|---|---|---|---|---|---|---|
| Handpump | | 22 | $3 | $98 | $16 - $45 | $28 |
| Mechanised borehole | Small | 17 | $2 | $114 | $39 - $72 | $52 |
| | Medium | 17 | $0 | $58 | $22 - $48 | $32 |
| Single-town system | Small | 2 | $78 | $95 | $82 - $91 | $87 |
| | Medium | 28 | $2 | $110 | $37 - $64 | $51 |
| | Intermediate | 3 | $21 | $61 | $27 - $47 | $33 |
| Multi-town system | Small | 6 | $28 | $133 | $47 - $112 | $79 |
| | Medium | 11 | $2 | $113 | $25 - $51 | $36 |
| | Intermediate | 1 | $46 | $46 | $46 - $46 | $46 |
| Mixed piped supply | Small | 8 | $41 | $192 | $59 - $102 | $79 |
| | Medium | 66 | $2 | $178 | $37 - $79 | $61 |
| | Intermediate | 6 | $7 | $45 | $12 - $36 | $22 |

Capital expenditure to develop the network source and facilitate storage and transmission[19] varies in a predictable manner between technologies. A single-town system requires greater onsite storage than a mechanised borehole, while expenditure on storage constitutes 16–36% of the capital costs of single-town systems compared to 5–12% for mechanised boreholes. The main expenditure on multi-town systems relates to the additional costs of connecting to a centralised water source; this represents between 30% and 70% of overall capital expenditure. These values vary greatly according to the distances between a community and the centralised source, with greater distance equating to greater costs.

differences between the delivery models. Rather, they act as a guideline in understanding how values fluctuated for each model. The intermediate sized multi-town scheme does not have an interquartile range as it only represents one (1) data point.

[19] In this context, the term "transmission" is used to refer to expenditure on connecting a community as a whole to a centralised surface water or ground water source. Piped infrastructure within the community to take the water to households or individual water points is described in this paper as network distribution.

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The majority of capital expenditure (82%) for a borehole with handpump is spent on developing and drilling the source. Another 13% relates to survey, planning or siting activities that are often not incorporated into published construction expenditure figures.

### 5.2.2 Maintenance expenditure on water systems

Maintenance expenditure is made up of day-to-day operating costs, such as salaries, electricity and routine maintenance (OpEx), as well as the cost of periodic major maintenance and renewal of the fixed asset base (CapManEx). The other aspects of recurrent costs – expenditure on direct and indirect support were not consistently collected across countries and are discussed separately in section 5.7.

Across all the piped networks, operational expenditure values were quite modest between $0.44 and $2.41 per person per year. This constituted between 1-6% of the initial capital outlay (Table 5-2).

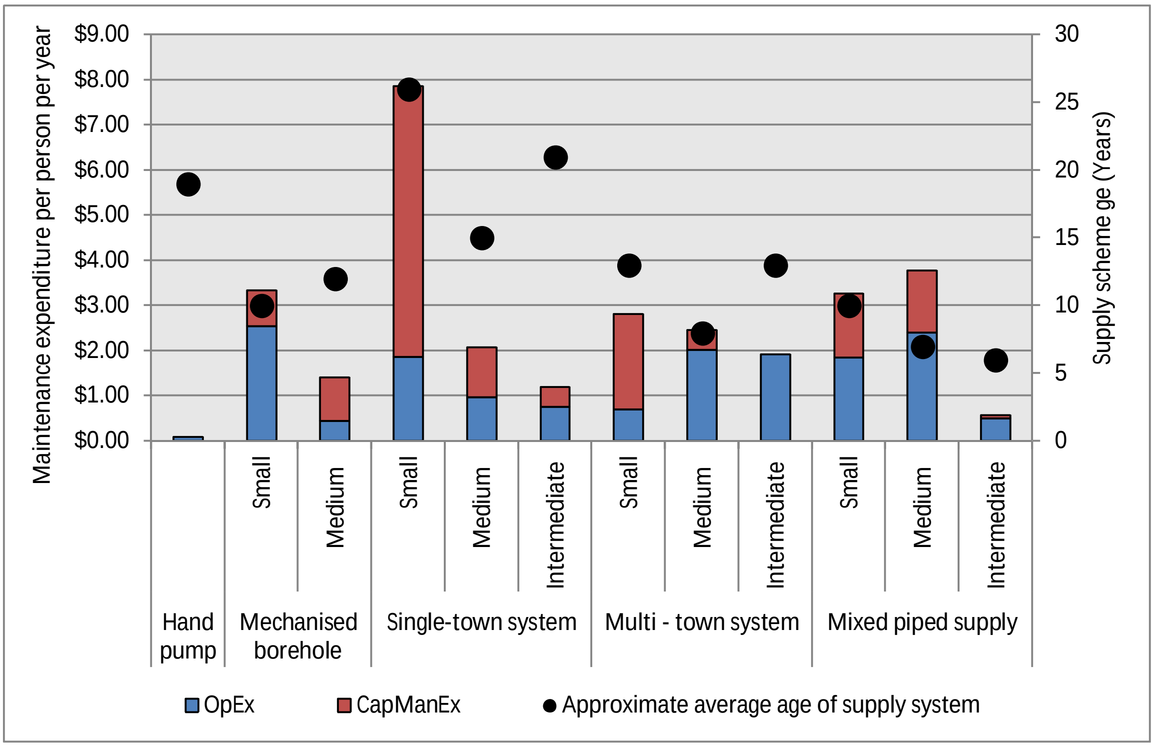
**Table 5-2: Mean annual recurrent maintenance expenditure per person per year on rural water systems in Andhra Pradesh**

| **Service delivery model** | **Service area size** | **Nº of systems** | **Mean system age** | **Operational expenditure (OpEx)** | | **Capital maintenance expenditure (CapManEx)** | |
|---|---|---|---|---|---|---|---|
| | | | | Mean | Inter-quartile range | Mean | Inter-quartile range |
| Borehole and handpump | | 1,094 | 19 | $0.09 | $ 0.0 - 0.0 | $0.00 | $ 0.0 - 0.0 |
| Mechanised borehole | Small | 17 | 10 | $2.54 | $ 0.4 - 3.4 | $0.79 | $ 0.0 - 0.3 |
| | Medium | 17 | 12 | $0.44 | $ 0.2 - 0.3 | $0.97 | $ 0.0 - 1.2 |
| Single-town system | Small | 2 | 26 | $1.87 | $ 1.4 - 2.1 | $5.99 | $ 4.9 - 6.5 |
| | Medium | 28 | 15 | $0.97 | $ 0.5 - 1.5 | $1.10 | $ 0.0 - 1.0 |
| | Intermediate | 3 | 21 | $0.75 | $ 0.6 - 1.0 | $0.44 | $ 0.1 - 0.2 |
| Multi-town system | Small | 6 | 13 | $0.70 | $ 0.1 - 1.1 | $2.11 | $ 0.0 - 0.0 |
| | Medium | 11 | 8 | $2.02 | $ 0.4 - 1.7 | $0.44 | $ 0.0 - 0.6 |
| | Intermediate | 1 | 13 | $1.91 | $ 1.8 - 1.8 | $0.00 | $ 0.0 - 0.0 |
| Mixed piped supply | Small | 8 | 10 | $1.84 | $ 0.3 - 1.4 | $1.42 | $ 0.0 - 0.8 |
| | Medium | 66 | 7 | $2.41 | $ 0.7 - 2.1 | $1.37 | $ 0.0 - 0.5 |
| | Intermediate | 6 | 6 | $0.51 | $ 0.2 - 0.6 | $0.07 | $ 0.0- 0.1 |
| All Together | | 187 | 11 | $1.44 | | $0.88 | |

The lowest levels of expenditure were recorded for borehole and handpump systems ($0.09 per person, per year). For each system, capital maintenance occurs at irregular intervals and consequently variations in expenditure between different technologies are much more pronounced than for operational and minor maintenance expenditure.

The highest levels of capital maintenance expenditure are reported for the oldest systems - the small single-town systems - with an average age of more than 26 years (mean CapManEx $5.99 per person per year - the red bars in Figure 5-2). However, amongst the other technologies there is no clear pattern between the mean system age and CapManEx. It should be kept in mind that service interruptions and breakdowns are very common in Andhra Pradesh (as fully explored in section 5.2.3) and that the actual expenditure on capital maintenance may not be an indication of the expenditure that is required to keep systems functioning.

**Figure 5-2: Mean annual maintenance expenditure per person with mean age of water system**



### 5.2.3 Water service levels

In Andhra Pradesh, household surveys were conducted in 103 out of the 187 communities where cost data collection had taken place therefore the service level analysis can only be undertaken for this restricted number of communities[20].

The availability of multiple supply sources in rural and small town areas means that more than 98% of all sampled households received the basic water quantity standard of 20 litres per person per day from formal sources, with some households receiving considerably more. The sheer number of water points and infrastructure available in these communities means that access to formal sources was not a significant problem, either in terms of crowding or time for collection. The total time taken to complete a round trip to collect water was used as the indicator for access. Across all systems the average time to fetch water was just six minutes; corresponding to “high” service level for access according to the WASHCost ladder[21].

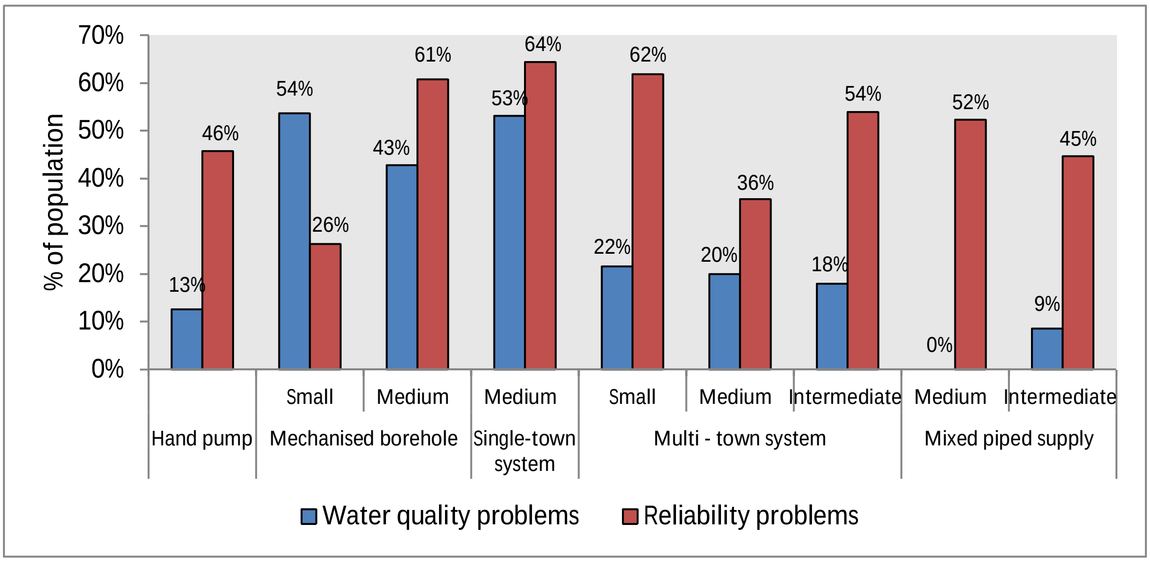
The two biggest factors precluding the delivery of a “basic” level of water service are water quality and reliability (Figure 5-3). Water quality was found to be a particular problem for mechanised borehole networks and the medium-sized single-town systems, where 43-54% of residents reported high dissatisfaction with water quality. Furthermore under each service delivery model, at least 25% of users did not achieve the criteria for basic service reliability, as these systems were found to be non-functional for more than 12 days a year[22].

Despite poor reliability of systems, the ability of households to be able to access a “basic” or better quantity of water from formal sources (≥20 lpcd) re-emphasises the resilience built into the service in India due to the availability of multiple point source supply options at the community and household level. This sets service

[20] No cost versus service level information is available for small and intermediate-sized single-town schemes, nor for small mixed piped supply scheme.
[21] Only households fetching water from streams and canals spent more than 10 minutes per trip (16 minutes).
[22] In Andhra Pradesh if a system was no working for between 12 and 17 days a year this was considered “sub-standard” for reliability. If the system did not work for 18 or more days this was classified as “no improved service” for reliability.

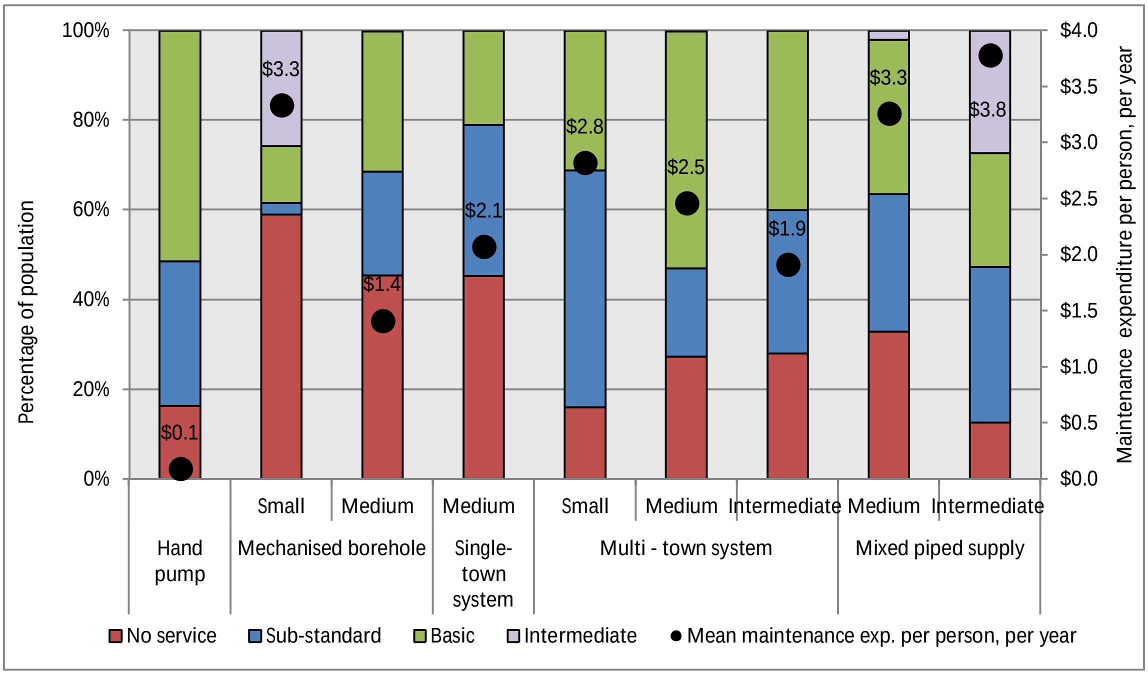
delivery in Andhra Pradesh apart from the African countries discussed in this paper where water points are scarcer.

**Figure 5-3: Percentage of households receiving a sub-basic water service in terms of water quantity and service reliability**




For these reasons the majority of households do not receive a basic level of service from water supply systems in Andhra Pradesh (Figure 5-4). At this aggregated level it is apparent that no single water service delivery model is providing an obviously better or worse level of service than any other. For piped systems the current levels of expenditure of between $1.4 and $3.8 per person, per year, are providing systems that are unreliable and where less than 50% of people are receiving a basic service.

**Figure 5-4: Combined service level per service area – showing combined operating and capital maintenance expenditure per person per year**




## 5.3 Burkina Faso

### 5.3.1 Capital expenditure on water systems

The mean capital expenditure per borehole and handpump system amongst the three regions in Burkina Faso was $13,382 (n=38), with an inter-quartile range of $11,476 to $15,281. This equates to a mean capital expenditure of $69 per person with an average of 194 people found to be using each source.

Five small mechanised boreholes were visited during the sampling but only two—those in Dossi and Komsilga—had sufficient expenditure data for analysis. An overview of the characteristics of these two networks is displayed in Table 5-3. In both cases the systems are only being used by a fraction of the people that they are designed to serve: The Dossi system has 255 users compared to a design capacity of 1,050 and the Komsilga system 216 users compared to a design capacity of 2,000.

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**Table 5-3: Details of small piped networks sampled in Burkina Faso**

| Details of the network | Dossi system | Komsilga system |
|---|---:|---:|
| Date of construction | 1997 | 2009 |
| Depth of borehole | 49 | 70 |
| Length of piped network (m) | 212 | 3,523 |
| Material of network | PVC | PVC |
| Storage capacity ($m^3$) | 10 | 20 |
| Number of public stand-posts | 2 (10 private connections) | 4 |
| Design number of users of the network | 1,050 | 2,000 |
| Actual number of users of the network | 255 | 216 |

This underuse of formal sources has a significant impact on expenditure calculations. According to the number of people the mechanised boreholes were designed to serve, the mean capital expenditure is $81 per person (design), but due to system underuse this corresponds to $586 per person (actual[23]) (Table 5-4)

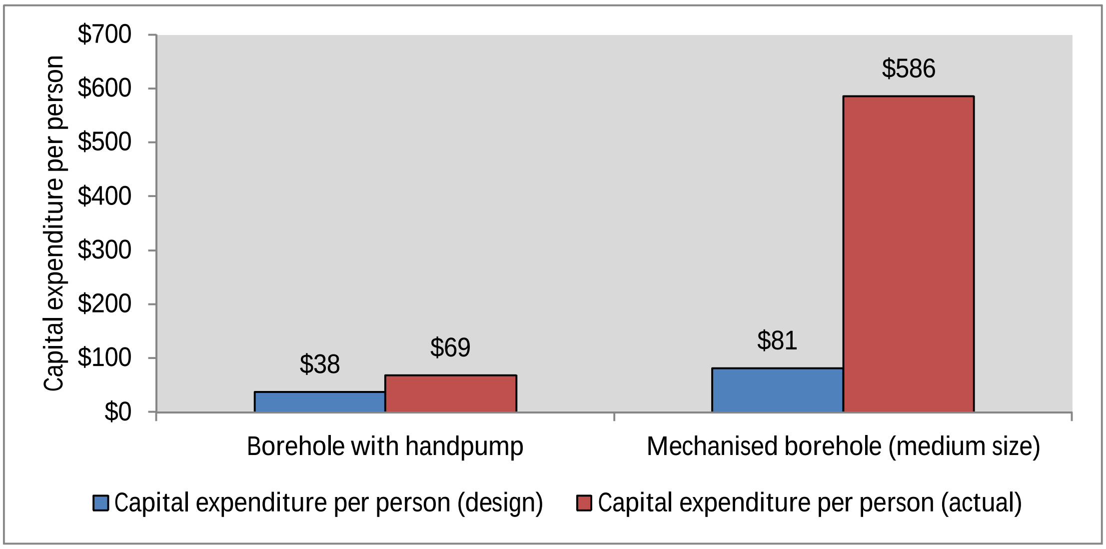
**Table 5-4: Capital and recurrent expenditure on small mechanised borehole systems in Burkina Faso**

| **Expenditure metric** | **Community with piped system** | **Capital expenditure** | | | | | **Annual recurrent exp.** |
|---|---|---|---|---|---|---|---|
| | | Source | Distribution network | Storage | Generator | Total | |
| *Total expenditure* | Dossi | $17,299 | $16,140 | $16,439 | $18,732 | $68,610 | $12,312 |
| | Komsilga | $57,822 | $66,879 | $40,056 | $30,277 | $195,034 | $5,676 |
| | **Mean** | **$37,560** | **$41,509** | **$28,247** | **$24,505** | **$131,822** | **$8,994** |
| *Expenditure per **design** population served* | Dossi | $16 | $15 | $16 | $18 | $65 | $12 |
| | Komsilga | $29 | $33 | $20 | $15 | $98 | $3 |
| | **Mean** | **$23** | **$24** | **$18** | **$16** | **$81** | **$7** |
| *Expenditure per **actual** population served* | Dossi | $68 | $63 | $64 | $73 | $269 | $48 |
| | Komsilga | $268 | $310 | $185 | $140 | $903 | $26 |
| | **Mean** | **$168** | **$186** | **$125** | **$107** | **$586** | **$37** |

[23] In this study the metric of analysis "per person (actual)" refers to the cost per person actually served by the water supply system in contrast to "per person (design)" which refer to the per person cost according to the number of people the system is designed to serve.

Expenditure per person (actual) on the small mechanised borehole systems is approximately nine times higher than the per person (actual) costs of boreholes with handpumps. The small sample size of the mechanised borehole networks means that this comparative difference may not hold true for the whole country.

**Figure 5-5: Capital expenditure per person for water systems in Burkina Faso**




### 5.3.2 Maintenance expenditure on water systems

The recurrent expenditure data collected on water systems in Burkina Faso consists of a detailed data set of operating and minor maintenance costs with occasional instances of capital maintenance.

For borehole and handpumps the mean annual maintenance expenditure was $37.83 (median $24.93) per system, which equates to a mean of $0.37 per person (actual) per year.

The expenditure on mechanised boreholes was considerably higher both in absolute terms and at the per person level. The mean maintenance expenditure mechanised borehole systems was $7.28 per person (design) per year according to the design population, but this equates to $37.28 per person (actual). The small sample size, and underuse, of the mechanised borehole systems means that these levels of expenditure may represent extraordinary, rather than typical expenditure.

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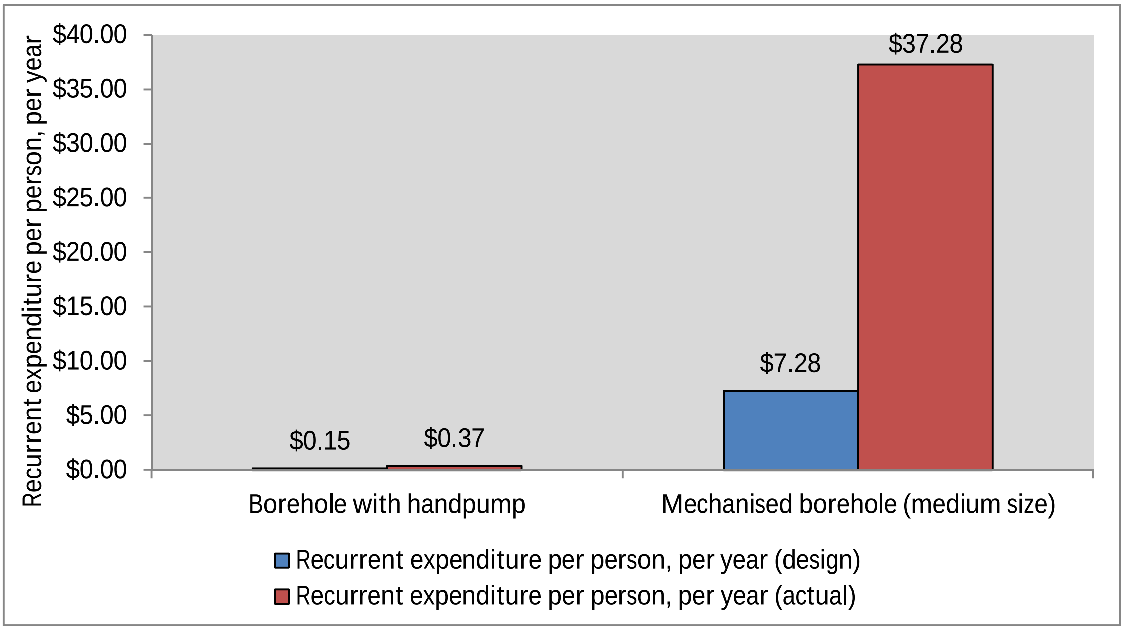
**Figure 5-6: Recurrent expenditure per person per year for water systems in Burkina Faso**



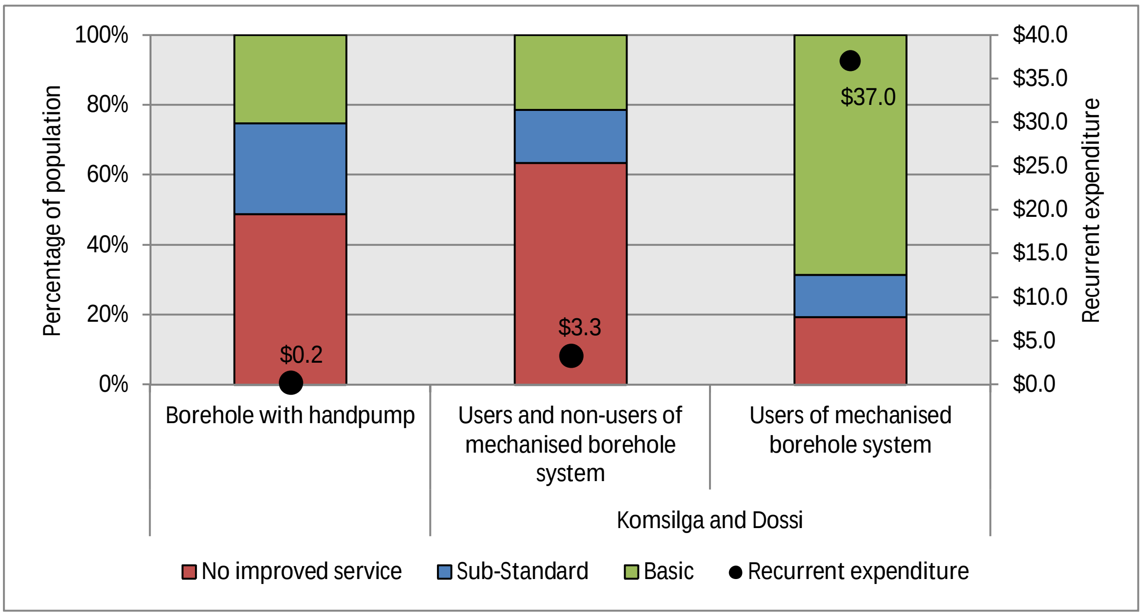

### 5.3.3 Water service levels

This section compares the level of water services delivered by boreholes with handpumps and mechanised borehole networks with the recurrent expenditure for each system. As with the cost data a distinction is made between the services received specifically by the users of the mechanised borehole system, and the services received by residents within the “service area” that these systems are designed to serve, but including those not actually using the system.

Figure 5-7 shows that boreholes and handpumps deliver one quarter (25%) of residents with a “basic” water service. This compares to 21% receiving a basic service in the mechanised borehole service area, and 63% of those actually using the mechanised borehole system.

The main barriers to service delivery for borehole and handpump systems are the quantity of water received by users (35% do not receive the basic requirement of 20lpcd) and the distance of households from the water point (48% are over 1 kilometre from the water point). In Komsilga and Dossi many of the households do not access the formal water system and therefore do not receive a sufficient quantity of water from an improved source. The households that do access the mechanised borehole system tend to receive a better water service than others in the service area but this comes at a substantially higher per person cost[24].

**Figure 5-7: Combined service level with recurrent expenditure per person per year for water systems in Burkina Faso**




## 5.4 Ghana

### 5.4.1 Capital expenditure on water systems

The primary source for capital expenditure was 82 construction contracts from three regions: Ashanti, Volta and Northern. This data has been disaggregated per activity. Lump sum capital expenditure data was also collected for 15 boreholes with handpumps as part of field collection. The comparison of these two data sets is shown in Figure 5-8.

[24] The reasons for the underuse of these mechanised borehole system were not definitively resolved. Research staff in Burkina Faso suggested that the higher tariff for water from mechanised borehole sources discourage wider use.

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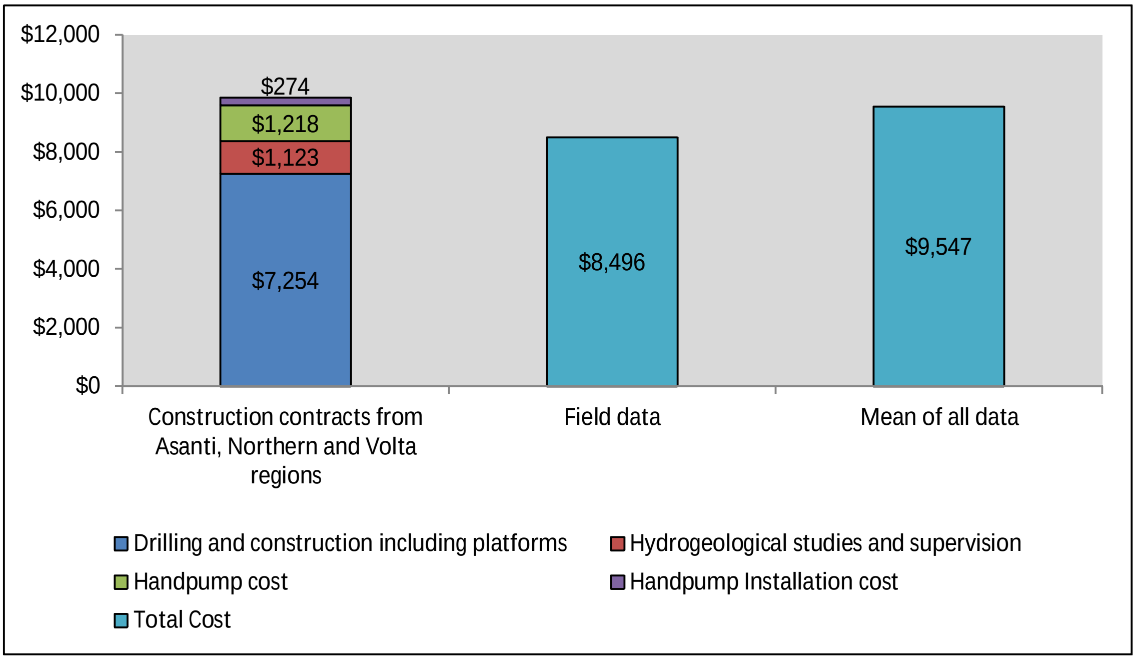
Figure 5-8: Average capital expenditure on borehole and handpump systems[25]




The recorded capital expenditure from construction contracts was $9,868 per system which is around 10% more expensive than the field data values of $8,946 per system. Collating these sources together gives a borehole and handpump arithmetic mean cost of $9,547 per system.

Boreholes with handpumps in Ghana are designed to serve 300 people, equating to a capital expenditure of $32 per person (design). Since each borehole with handpump was used by an average of 458 people, expenditure per user is reduced by more than a third, amounting to $21 per person (actual).

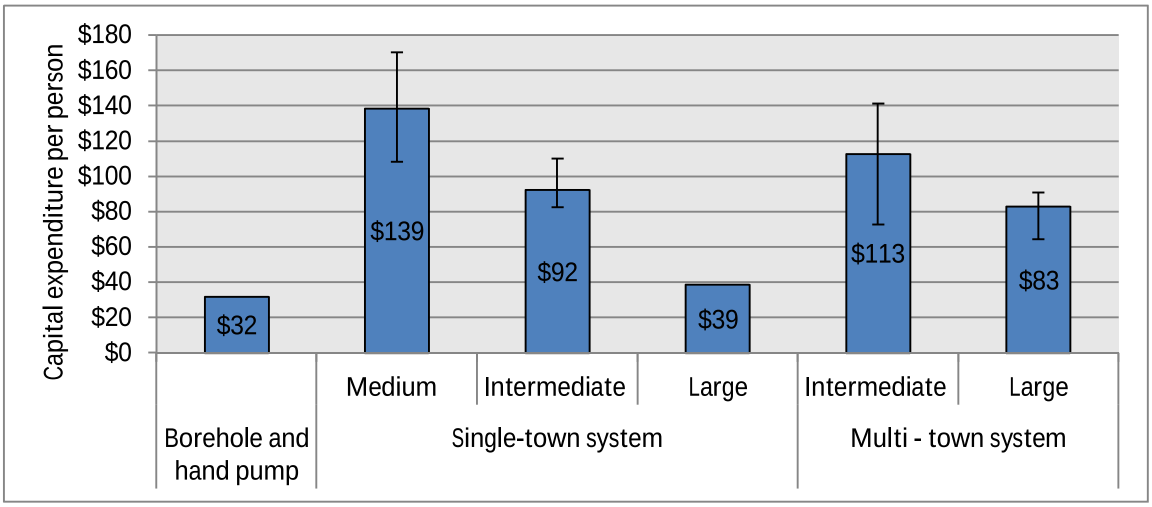
Capital expenditure data was collected and analysed for piped systems serving 48 small towns. The most common systems sampled were medium sized (serving between 500 and 5,000 people), but there are also large networks serving nearly 20,000 people.

[25] Analysis of the field data showed that those systems constructed before 2007 cost on average $24,538 to construct – over three times the average cost after 2007. The pre-2007 costs have therefore been excluded as they are not representative of current system costs.

Capital expenditure per person decreases for single-village/town and multi-town systems as the size of the networks increase – suggesting an impact of economies of scale (Figure 5-9). The medium-sized, single-village/town systems were, on average, the most expensive to construct at $139 per person (interquartile range $108-170); a third more expensive than the $92 (interquartile range $82–110) spent on intermediate single-village/town systems. The mean expenditure on the intermediate multi-village/town systems was $113 (interquartile range $73-141), 18% higher than the equivalent single-village/town system. Moreover, the large multi-village/town system at $83 (interquartile range $64-91) was more than twice the cost of the equivalent single-village/town system. The mean capital expenditure across all piped systems is $104 per person (actual)[26].

Although the sample size for large single-village/town systems and multi-village/town systems is small, indicative findings show that contrary to the situation in Andhra Pradesh, comparable sized multi-town systems can be marginally more expensive to construct than single-town systems.

**Figure 5-9: Capital expenditure per person (actual) on water systems in Ghana, with interquartile ranges**




[26] In Ghana the actual number of users of the piped systems was not collected as part of household surveys. Instead the number of people living in the service area covered by the piped system are considered to be served meaning there is no difference in the "per person (actual)" and "per person (design)" values. This does introduce extra layer of uncertainty to these figures.

Capital expenditure per person (actual) for boreholes with handpumps is shown to be well below expenditure per person for any of the piped supplies, in most cases four to five times less. This suggests that transitioning from a handpump based service delivery model to a piped supply model requires a five-fold increase in capital investment costs, from $21 to $104 per person.

### 5.4.2 Maintenance expenditure on water systems

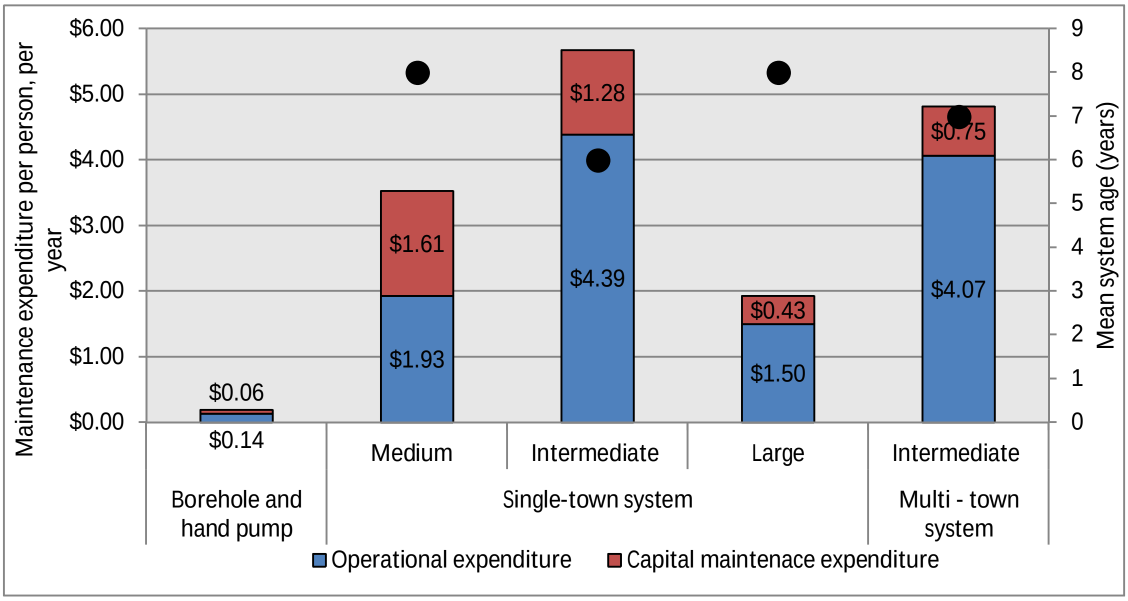
For boreholes and handpumps operational and capital maintenance expenditure was gathered for 47 boreholes with handpumps systems. The maximum annual recurrent expenditure encountered for a single borehole was very high, at $421. However, typical values were much lower with a mean expenditure of $62 translating to $0.20 per person (actual) per year.

Recurrent expenditure on single and multi-town systems was only available for 8 of the 48 locations visited during primary data collection. This data was therefore augmented with information from 16 networks collected through regional offices of the Community Water and Sanitation Agency (CWSA) - a government agency in charge of facilitating the provision of safe drinking water and related sanitation services to rural and small town communities in Ghana.

The intermediate sized single-village/town systems incurred the highest annual operating expenditure, with a mean of $4.39 per person, more than twice the total for other single-village/town systems (medium sized system mean $1.93, large size system mean $1.50), and marginally higher than intermediate sized multi-village/town system (mean $4.07). Mean capital maintenance expenditure on small town systems is lower than operational expenditure, with the range for all systems falling between $0.43 and $1.61 per person per year. All the systems were constructed in the last 10 years and it is therefore reasonable to assume that the majority do not yet require significant capital maintenance of the distribution or transmission networks – although mechanical and electrical components have shorter design lives and may be failing.

The per person (actual) maintenance expenditure (operational plus capital maintenance) is found to be between 10 to 30 times higher for piped networks compared to traditional borehole and handpump supply.

**Figure 5-10: Comparison of operational and capital maintenance expenditure per person (actual) per year**




### 5.4.3 Water service levels

Service level data was collected in five communities served by small-village/town systems and 31 rural communities served by boreholes with handpumps[27].

The majority of persons receive a basic quantity of water from both these technologies. Piped networks generally provide more water per person per day (36 lpcd), than boreholes with handpumps (24 lpcd), and larger networks provide a greater quantity than smaller ones. Water points are, on average, provided at an acceptable distance from users (i.e., less than 300m) under both service models.

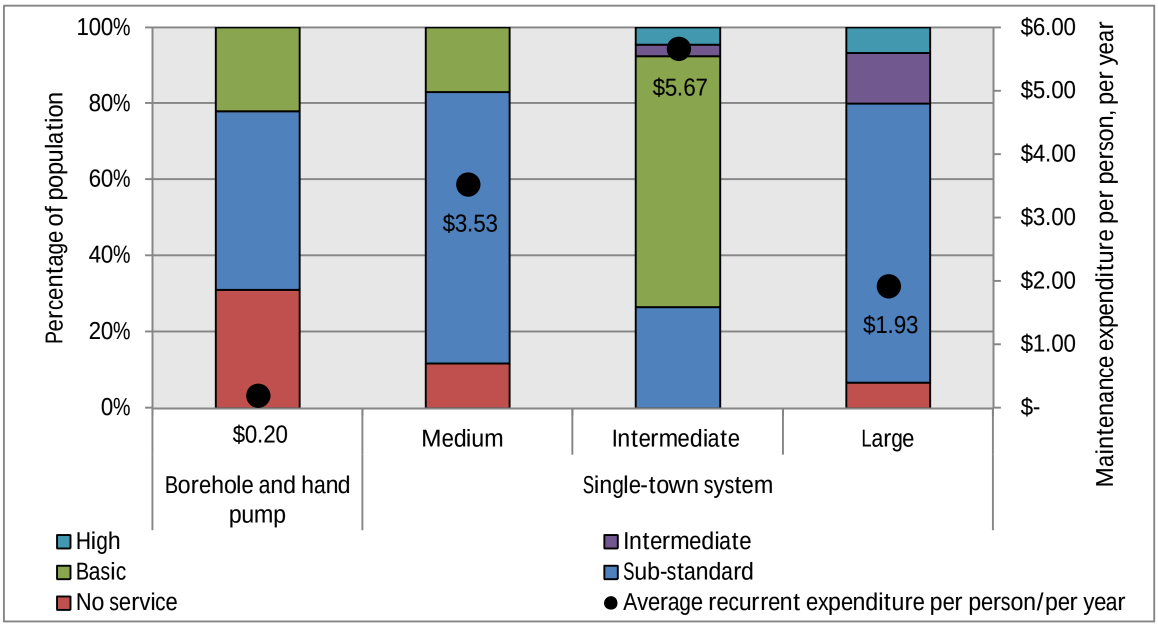
The principal barrier to achieving a basic level of service is the lack of sufficient functional water points to meet the service level norm of one source per 300

[27] This sample does not cover communities served by multi-town networks and a comparison of expenditure and service level cannot be done for this service delivery model.

users. Indeed, for three out of the water supply technologies, more than 50% of users access an overcrowded source. Not only does this mean that users are much more likely to spend an unreasonable amount of time accessing water, but it may also make water points more susceptible to breakdown due to constant use.

The only approach that does not experience overcrowded sources is the intermediate single-town system, and as a consequence, it achieves the highest service levels with 73% of the users attaining at least a basic level of service for all indicators. In contrast, more than two thirds of users in the rest of the sample receive either a “sub-standard” or a “no improved service” score (Figure 5-11).

**Figure 5-11: Combined service level per technology, with total maintenance expenditure per person per year**




In contrast to what may be expected, piped networks do not necessarily provide a better overall service to users than the boreholes with handpumps according to WASHCost service levels. However, it is telling that while many piped systems primarily face problems with source crowding, boreholes with handpumps face additional problems of inadequate water quality testing, greater unreliability of supply with fewer users receiving an adequate quantity of water.

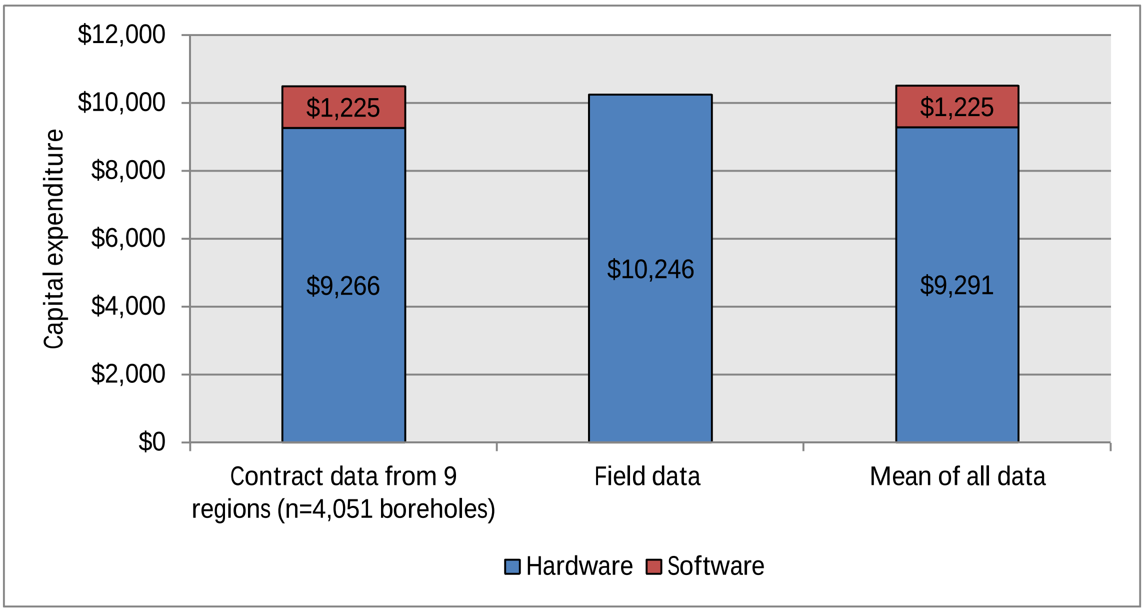
In summary, data from Ghana shows that it takes a five-fold increase in capital expenditure - from $21 to 104 per person - to transition from boreholes with handpumps to a piped supply. At present level the annual maintenance expenditure on piped systems is up to 30 times greater than boreholes and handpumps.

## 5.5 Mozambique

### 5.5.1 Capital expenditure on water systems

The primary source of capital expenditure data is based on the analysis of national contract records sourced from the National Information System for Water and Sanitation (SINAS). The SINAS database details both hardware and software expenditure for more than 4,000 boreholes. The WASHCost field sample yielded only four valid capital expenditure data points for boreholes with handpumps. An overview of these capital expenditure values is shown in Figure 5-12.

**Figure 5-12: Mean capital expenditure on borehole and handpumps**

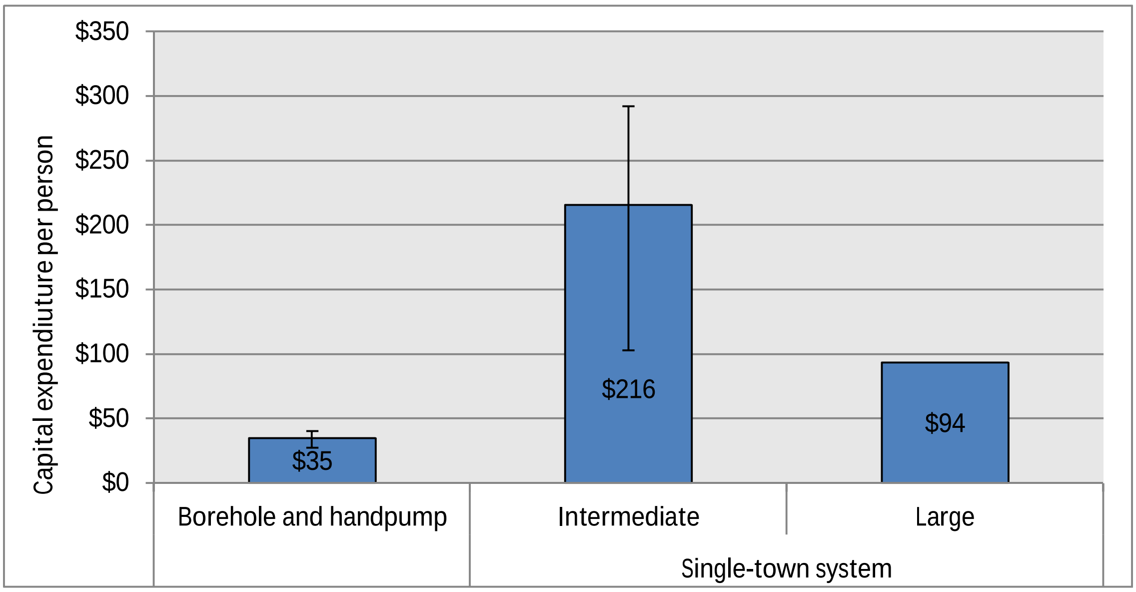



The mean hardware expenditure on constructing a borehole and handpump system across all the contracts was $9,266, around 10% less than the $9,575 recorded from boreholes sampled in the field. Across all data sources the combined capital and software costs of $10,516, equates to $35 per person (actual and design) assuming 300 users per system.

From the ten valid capital expenditure values collected for single-village/town systems, nine relate to intermediate networks serving between 5,000 and 15,000 people, and the other to a large network serving just over 17,000 people.

The mean capital expenditure on intermediate networks is $216 per person (actual), more than double the per person cost of the single large network samples (mean $94 per person). It is noteworthy, however, that the CapEx values from the nine intermediate networks varied sharply from a minimum of $32 per person to a maximum of $407 per person, meaning that intermediate networks are not always more costly than larger equivalents. The average CapEx for borehole and handpump systems is one sixth of that for intermediate piped networks, and approximately a third of that for the large piped network (Figure 5-13).

**Figure 5-13: Mean capital expenditure per person (actual) on water supply systems in Mozambique, with inter-quartile ranges**




### 5.5.2 Maintenance expenditure on water systems

At current costs, the mean annual operational expenditure on a borehole and handpump system is $37 (inter-quartile range of $12 to $50), which corresponds to an expenditure of $0.11 per person per year. Field teams were unable to collect capital maintenance expenditure for boreholes with handpumps, Indicative CapManEx values were collected from maintenance contract data but these do not relate to any boreholes in the sample and therefore have not been included in this historical cost analysis – however they are used as a basis for ideal cost forecasting (section 5.10).

Operational expenditure on piped systems was available for just three systems – two intermediate sized and one large. The mean annual expenditure on the two intermediate sized systems was $3.87 per person (actual), slightly less than the large system ($4.80 per person). The operational and maintenance expenditure on the medium piped system was sufficiently detailed so it could be disaggregated into separate activities. This shows that expenditure on salaries and electricity constituted 73% of total annual operational expenditure with only a small percentage (<4%) being spent on replacement materials. This suggests that the fixed costs and certain variable costs such as electricity bills are the only costs that are being met to maintain a bare minimum of services. Spending such a small proportion of operational expenditure on materials for repairs suggests that system leakages are not being adequately prioritised.

No valid capital maintenance was available for any of the single-town systems, and the values remain unknown.

The comparison of operational and maintenance expenditure between systems shows that the per person (actual) expenditure on the piped systems is between thirty to forty times higher for piped systems compared to borehole and hand pump systems (Figure 5-14).

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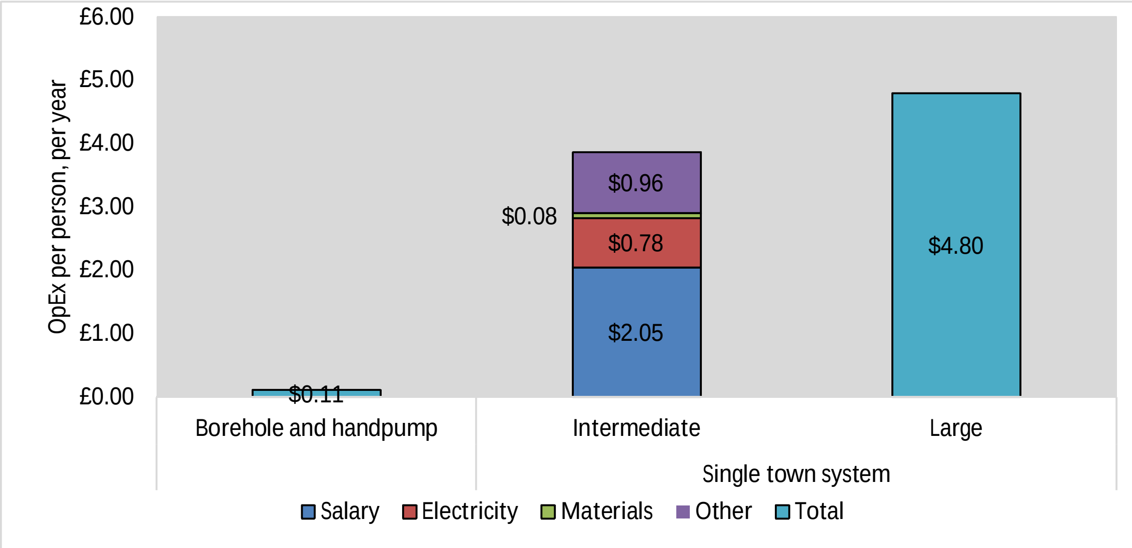
**Figure 5-14:** Mean operational expenditure per person (actual) on water supply systems in Mozambique




### 5.5.3 Water service levels

Of the 1010 surveys undertaken, 816 households were in service areas served by boreholes and hand pumps, and 196 households were served by medium and intermediate sized single-village/town systems[28]. From these surveys it is clear that in these service areas a proportion of residents use a mixture of formal and informal water sources to access drinking water at different times. This is most clearly seen in medium sized single town networks where 42% of resident's access mixed sources, compared to 39% in communities with boreholes and hand pumps and 18% in intermediate sized communities.

As a consequence those using mixed sources tend to access less water than those using formal sources only. This contributes to over 70% of residents not receiving a basic 20 lpcd quantity of water from either boreholes with hand pumps, or from medium and intermediate piped systems (Table 5-5).

[28] Service level data is not available for large single-town systems.

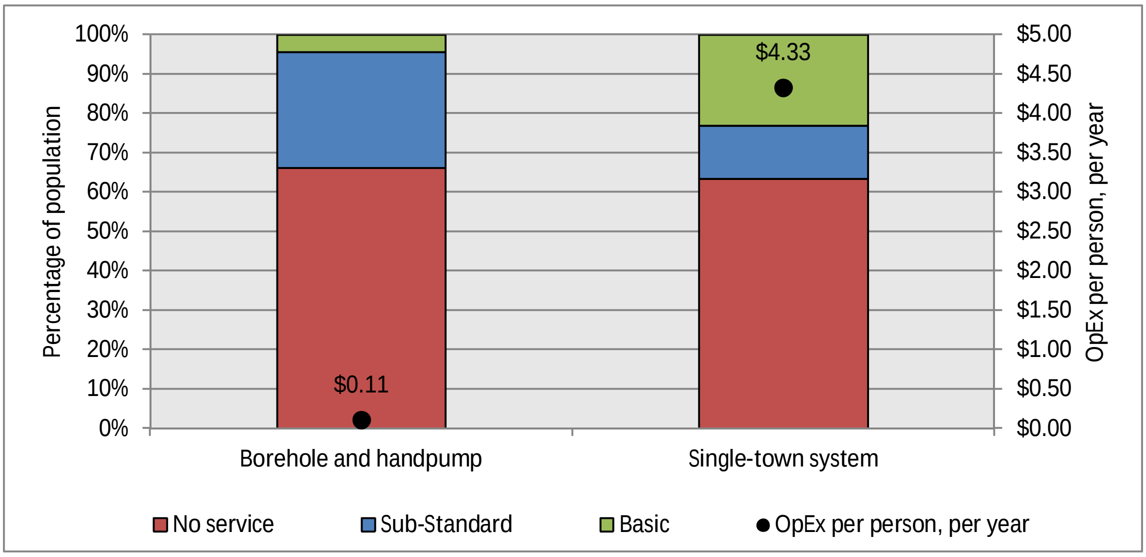
**Table 5-5: Quantity of water received (litres per person, per day)**

| Service delivery systems | Service area size | Water quantity (lpcd) | % of population receiving a water quantity of 20 lpcd |
|---|---|---|---|
| Boreholes with hand pumps | | 12 | 22% |
| Single-town system | Medium | 12 | 23% |
| | Intermediate | 18 | 32% |

The use of alternative sources clearly has a major impact on the service levels achieved in a particular service area. The combined service level—incorporating indicators on water quantity, accessibility and reliability (the water quality indicator was unreliable and has been excluded) reflects this, showing that only 5% of those drawing their water from boreholes with hand pumps receive a basic water service, compared to 23% accessing a piped system. Those with access to a piped system also find that these sources are marginally more accessible (standpipe is near and less crowded than the borehole and hand-pump option).

Eighteen per cent more people are found to receive a basic service from the piped systems in Mozambique than from the borehole and handpump systems, but these come at a significantly higher capital cost – as analysed in section 5.5.1 – and over forty times the ongoing maintenance cost (Figure 5-15).

**Figure 5-15: Combined service level per technology, with operational and maintenance expenditure per person per year**



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## 5.6 Sierra Leone

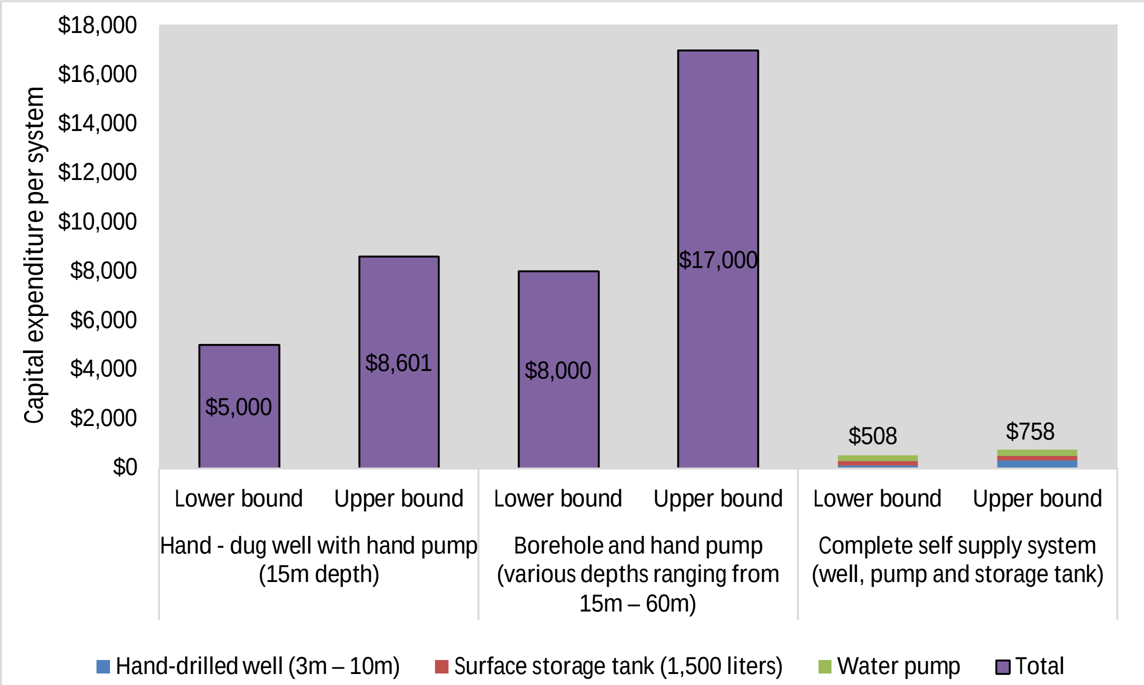
In Sierra Leone the construction of new hand-dug well with handpump and borehole and handpump systems is almost entirely financed by either central government or donor programmes. As a consequence primary data of actual capital expenditures were rarely encountered within district councils or the National Water Directorate. Therefore secondary sources and expert opinion were used to derive a credible range of capital cost estimates for point source systems. Similarly the capital costs of self-supply water systems were derived from three sources: 1) general bill of quantity estimate of cost of materials required to construct the self-supply systems; 2) actual costs paid by households that have purchased these systems in Kenema district; and 3) cost estimations according to a focus group discussion amongst WHH trained self-supply technicians.

An excellent evidence base of operational and minor maintenance expenditure was collected from quantitative evidence collated from community WASH committees and through collaboration with InterAide – a French NGO operating in Bombali district - who have been documenting the recurrent maintenance costs of hand-dug well and handpump systems. This was analysed alongside field data.

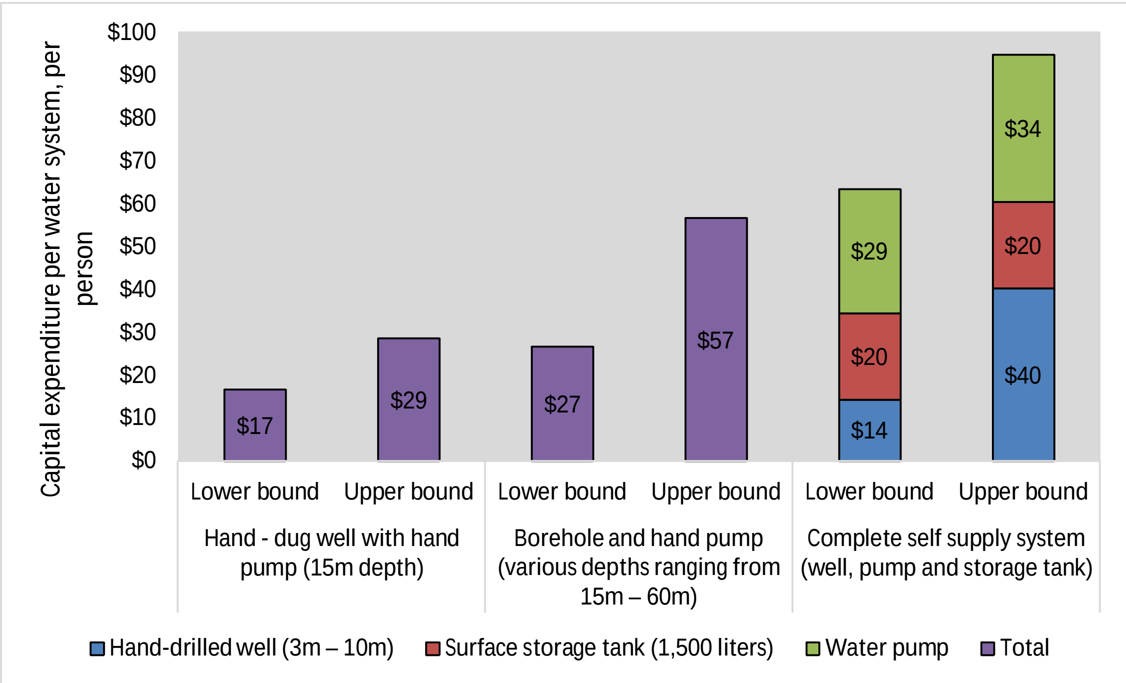
### 5.6.1 Capital expenditure on water systems

Due to the absence of capital expenditure values from community sources estimated values for hand-dug well with handpump, borehole and handpump, and self-supply systems were derived from various primary and secondary source. The resultant values, including lower and upper bound estimates, are shown in Figure 5-16; whereas Figure 5-17 details the per person capital expenditure on each system according to their respective number of users (assumed or actual).

### Figure 5-16: Capital expenditure per water system in Sierra Leone




### Figure 5-17: Capital expenditure per water system, per person[29] in Sierra Leone

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[29] It is assumed that there are 300 users of each hand-dug well or borehole and handpump system – in line with the national guidelines - compared to 8 users of the self-supply system as determined by household surveys.

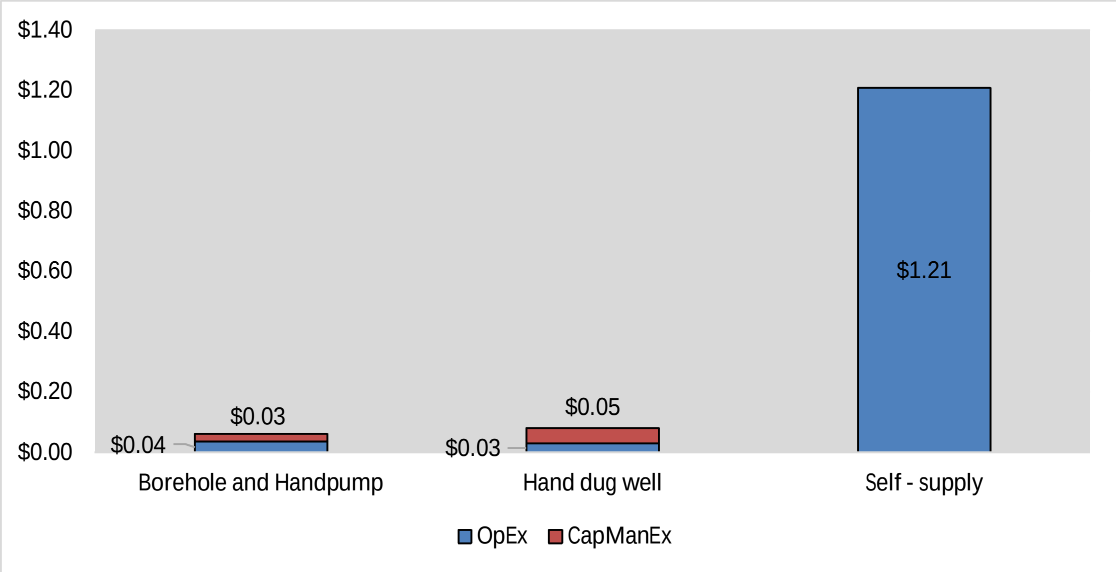
At the per person level the typical capital expenditure on self-supply systems (upper-bound: \$95, lower-bound: \$64) are found to be higher than borehole and handpump systems (upper-bound: \$57, lower-bound: \$27) and hand-dug well with handpump systems (upper-bound: \$29, lower-bound: \$17). This is despite the fact the absolute cost of self-supply system is considerably less than either the hand-dug well or borehole and handpump systems. This reflects the potentially greater affordability challenge posed by private household financed solutions such as self-supply, as opposed to community managed and financed systems.

### 5.6.2 Maintenance expenditure on water systems

Empirical evidence of maintenance expenditure was collected directly as part of field sampling and also indirectly through the French NGO InterAide which provided the recorded annual community operating expenditure for 377 systems. Across all the data sources the mean operational expenditure on borehole and hand-dug well systems range from \$9.20 – \$13.33 per year, compared to \$7.20 per year for self-supply systems. The annual capital maintenance expenditure tended to be higher for hand-dug well systems (mean \$15.12) compared to borehole and handpump systems (mean \$7.99). There was not any CapManEx data available for the self-supply systems sampled as these have been constructed within the last 12 months and major breakdowns had yet to occur.

Figure 5-18 shows that per person, recurrent maintenance expenditure on the point source systems sampled is minimal at between \$0.03 and \$0.06 per year, considerable lower than the \$1.21 per person, per year spent on self-supply systems.

**Figure 5-18: Comparison of mean maintenance expenditure on water systems per person per year**




### 5.6.3 Water service levels

For the community point source systems (hand-dug well with handpump and borehole and handpump) the main barrier to achievement of a “basic” service was the quantity of water accessed (Figure 14). Just over one fifth (21%) of people accessing a borehole and hand pump achieved the “basic” water quantity threshold of 20 lpcd, compared to just 14% of people using hand-dug wells with handpumps. In addition just under of quarter (24%) of hand-dug wells were found to have extended periods of non-functionality (>12 days a year) compared to 11% of boreholes and handpumps. The cumulative effect of these failures to meet water quantity and reliability standards is that just 10% of hand-dug well with handpump users and 20% of borehole and handpump users achieve a “basic” water service.

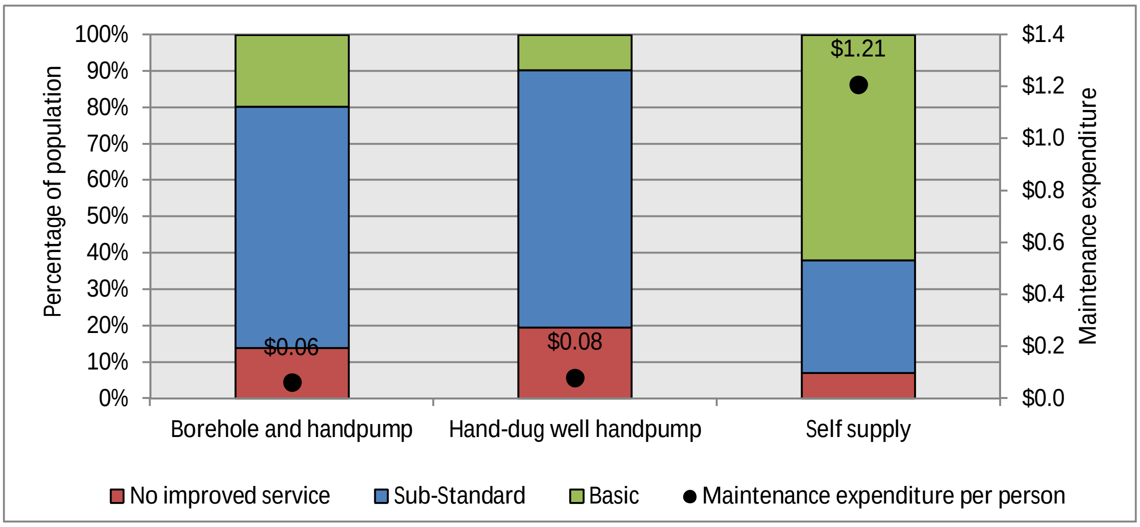
The analysis of self-supply[30] service levels shows a much greater proportion of users (62%) achieve a basic water service (Figure 5-19). In contrast to community source, self-supply systems are being repaired more promptly (90% of systems

[30] It should be noted that the self-supply service level based on a small sample of just 16 households

achieving a “basic” level of reliability – despite some minor breakdowns), and users on average receive a greater quantity of water (mean 20lpcd).

Existing levels of expenditure by the owners of self-supply systems (mean $1.21 per person, per year) are much higher than the equivalent level of expenditure on point source systems by community members (between $0.06 and $0.08 per person, per year) and correspondingly between 40% and 50% more users receiving a “basic” water service. This seems to reflect a higher willingness and ability to pay by households with self-supply systems compared to those with community owned systems.

**Figure 5-19 Combined service level per technology, with total maintenance expenditure per person per year**




## 5.7 Remaining components of recurrent expenditure

Expenditure on direct and indirect support was collected in three countries, with no data currently available for Burkina Faso. In India, estimates were based on budgetary allocations by the Andhra Pradesh State Government: apportioning these costs to the rural population gives a direct support expenditure of $0.30 per person per year.

In Ghana, expenditure on direct support was collected from District Water and Sanitation Teams (DWST) tasked with monitoring the functionality of water schemes, as well as from the CWSA, in charge of supporting both district and community service delivery.

The expenditure by the CWSA in supporting service delivery was determined as a single figure for all rural and small town areas at $0.37 per person per year. Expenditure by water and sanitation teams varied from district to district from a minimum of $ 0.07 per person per year in East Gonja district (Volta region) to a maximum of $ 0.24 in Bosomtwe district (Northern region). The combined average of both the DWST and CWSA amounts to $0.47 per person per year.

In Mozambique, expenditure on directly supporting service delivery is the responsibility of local government; although financial data was only available at national level and therefore does not incorporate specific local expenses. The annual national level expenditure allocated to supporting service delivery equates to a negligible per person expenditure of $0.0012 (just over one tenth of one cent). Since 2008, responsibility for direct support across 38 of the 128 districts in Mozambique has been contracted out to NGOs and private firms as part of what is termed PEC Zonal support. The annual per person expenditure on PEC zonal varied from $ 0.2 – $ 4.7 across a sample of 94 contracts in support of water and sanitation services. The average expenditure for those districts receiving PEC Zonal support was $1.10 per person, half of which (i.e., $0.55) can be attributed to the direct support costs for water (Zita and Naafs, 2011a). In non-PEC zonal areas, expenditure was almost zero (i.e., just $0.0012 per person). Across all the research areas, direct support expenditure averaged at $0.17 per person. However, this figure is not representative of what will happen if and when PEC is delivered to more districts around the country.

In each country study, expenditure on direct and indirect support was given as lump sum figures at district, regional or national level. As a consequence analysis could not be differentiated between different models of water supply, and values are therefore the same for handpump and piped supplies.

No cost of capital—in the form of interest payments or other returns to providers of capital—was found for any water system.

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The total recurrent expenditure per user per year can be calculated by adding the operational expenditure, the capital maintenance expenditure, the direct and indirect support costs, and the cost of capital

## 5.8 Cross country comparison of water system expenditure and service levels

This section brings together the capital and recurrent expenditure for all the water systems found in Andhra Pradesh, Burkina Faso, Ghana, Mozambique and Sierra Leone. Although sample sizes are very different for each of the countries and findings are context-specific, this section provides valuable information largely missing in the rural water sector namely comparisons of the levels of expenditure and quality of services delivered between water technologies and between countries.

### 5.8.1 Capital expenditure

The capital expenditure values for all systems sampled are shown in Figure 5-20. Of the five country data sets presented the lowest capital costs of water supply system construction are found in Andhra Pradesh, India. Piped systems of comparable type and size in Andhra Pradesh are found to be less than half the capital cost of those in Africa, and sometimes they are as little as one seventh of the cost – as with the intermediate piped schemes Andhra Pradesh (mean $33 per person) compared with the same systems in Mozambique (mean $216 per person). Amongst the African countries piped schemes, capital expenditure per person was found to be highest in Burkina Faso (mean $586 per person) where the mechanised borehole systems were found to be largely underused. Capital expenditure in Ghana was highest for small single-town systems (mean $139 per person), although the capital expenditure on multi-town systems was higher than single-town systems, when the schemes were of similar size.

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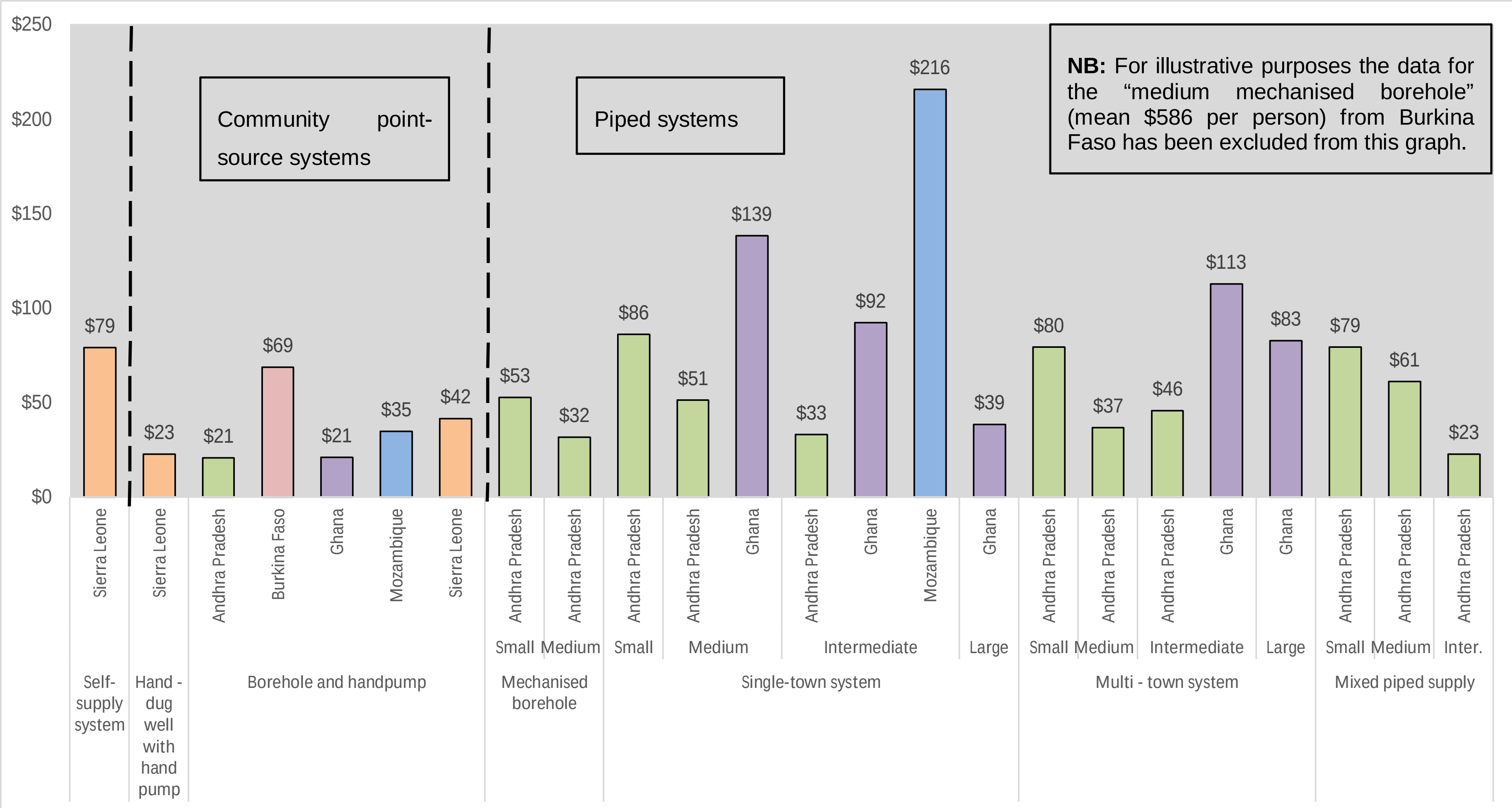
**Figure 5-20: Comparison of capital expenditure per person (actual) for all water systems sampled**



In both Ghana and Andhra Pradesh there is clear evidence of impact of economies of scale on piped systems, where per person expenditure decreases linearly as system size increases. The service level analyses in these countries (sections 5.2.3 and 5.4.3) do not show any consistent positive or negative relationship between the size of the system and the level of services achieved by users, indicating that the cost efficiencies of going to scale are not being off-set by a reduction in services to users.

Borehole and handpumps are the only technology where data was available in each of the five countries. In Andhra Pradesh the mean cost of constructing a borehole and handpump is $1,954 per system, less than a fifth of the cost of the cheapest system in Africa. The highest capital expenditure was found in Burkina Faso (mean $13,382), which is 40% higher than the $9,547 spent in Ghana, and 44% higher than the $10,516 spent in Mozambique. In Sierra Leone the estimated cost of a borehole and hand-pump is $12,500 but this could not be verified through field data.

Intra-country variations in the number of people using borehole and handpump systems, most notably the relatively uncrowded systems in Andhra Pradesh, results in a much closer alignment of capital expenditure values per person whereby the joint lowest mean values are found in Ghana and Andhra Pradesh ($21) ranging up to the highest values in Burkina Faso ($69) (Table 5-6).

**Table 5-6: Borehole with handpump capital expenditure per person (actual) and per system**

| Country | Mean cost per system | Number of people served (actual) | Cost per person (actual) |
|---|---|---|---|
| Andhra Pradesh | $1,954 | 94 | $21 |
| Burkina Faso | $13,382 | 194 | $69 |
| Ghana | $9,547 | 458 | $21 |
| Mozambique | $10,516 | 300 (assumed) | $35 |
| Sierra Leone | $12,500 | 300 (assumed) | $42 |

Amongst the African countries the mean per person capital cost of piped systems is between two and six times more costly than community point sources. In contrast the consistently lower construction costs found in India mean that some of medium and intermediate sized piped systems are cheaper, per person, in Andhra Pradesh than borehole and handpump systems in Africa.

All these capital expenditure values have been collated, per technology, in Table 5-7. Cost ranges show the indicative CapEx values for different water supply technologies in India (Andhra Pradesh state), and a separate field showing the found CapEx ranges across the four African countries.

**Table 5-7: Capital expenditure per person - cost ranges per technology**

| Water supply technology (all sizes) | Countries where data was collected | Range - capital expenditure per person (Andhra Pradesh only) | Range - capital expenditure per person (only African countries) |
|---|---|---|---|
| Self-supply | Sierra Leone | - | $64 - $95 |
| Hand-dug well with handpump | Sierra Leone | - | $17 - $29 |
| Borehole and handpump | Andhra Pradesh, Burkina Faso, Ghana, Mozambique, Sierra Leone | $21 | $21 - $69 |
| Mechanised borehole | Andhra Pradesh, Burkina Faso *(data not representative)* | $32 - $53 | - |
| Single town scheme | Andhra Pradesh, Ghana, Mozambique | $33 - $86 | $39 - $216 |
| Multi town scheme | Andhra Pradesh, Ghana | $37 - $80 | $83 - $113 |
| Mixed piped supply | Andhra Pradesh | $23 - $79 | - |

## 5.8.2 Maintenance expenditure

The combined expenditure on operational and minor maintenance and capital maintenance for each of the systems sampled are shown in Figure 5-21.

This figure effectively highlights that in all cases expenditures on community point sources are very low - with mean country values ranging from $0.06 - $0.37 per person, per year – and are much lower than maintenance expenditure on piped systems ($1.19 and $7.86 per person, per year for 16 out of the 18 different piped technologies sampled)

As with the capital expenditure data, there is evidence of economies of scale amongst the piped systems, particularly in Andhra Pradesh, where the per person expenditure on maintenance decreases with system size. However across all piped system maintenance expenditure is found to be very varied with no single technology or approach consistently reporting greater or lesser levels of expenditure. This variation may be expected as the country analyses showed the irregularity of capital maintenance expenditure varying with system age and timeliness of maintenance.

**Figure 5-21: Comparison of maintenance expenditure per person (actual), per year for all water systems sampled**

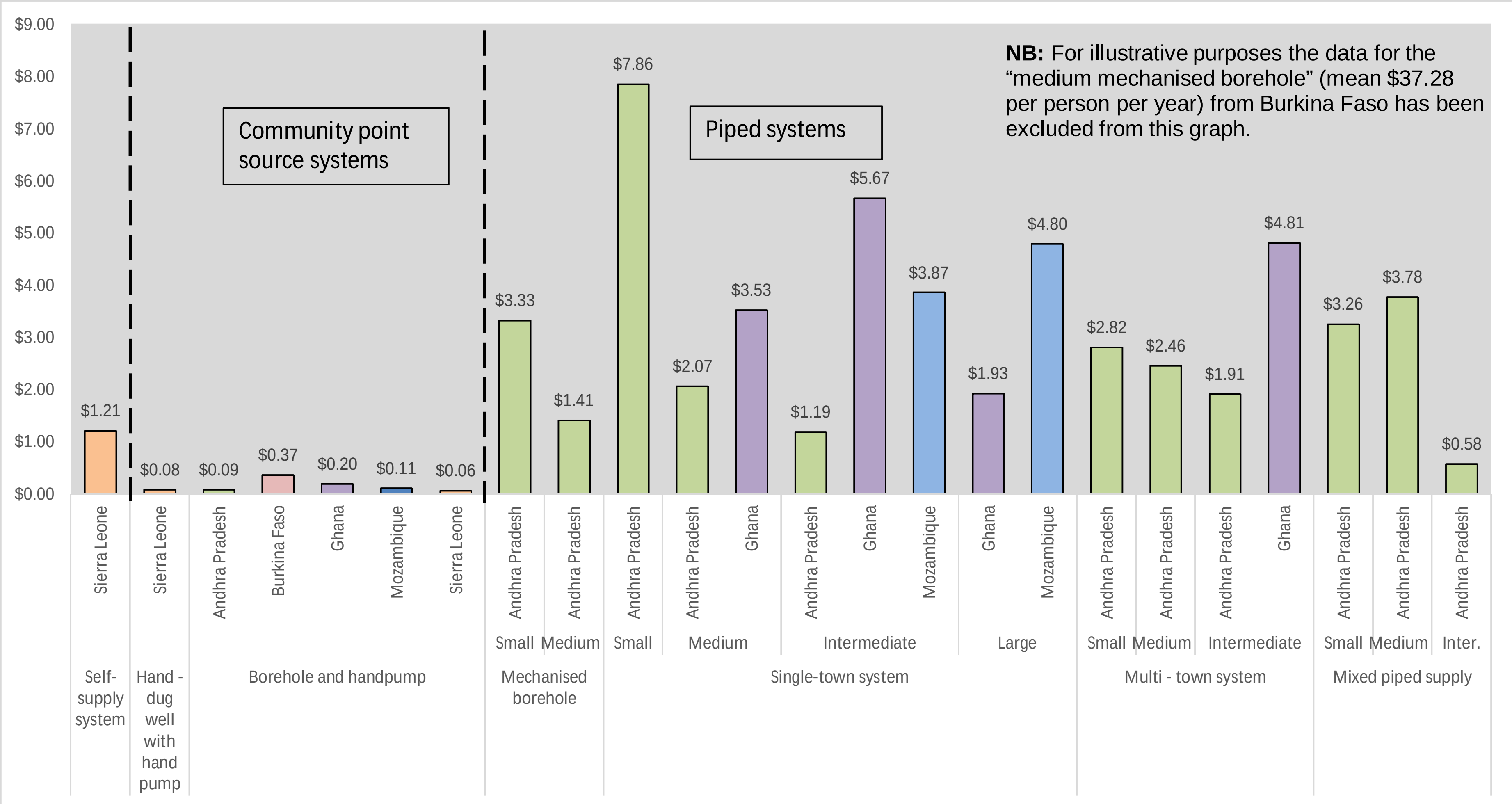
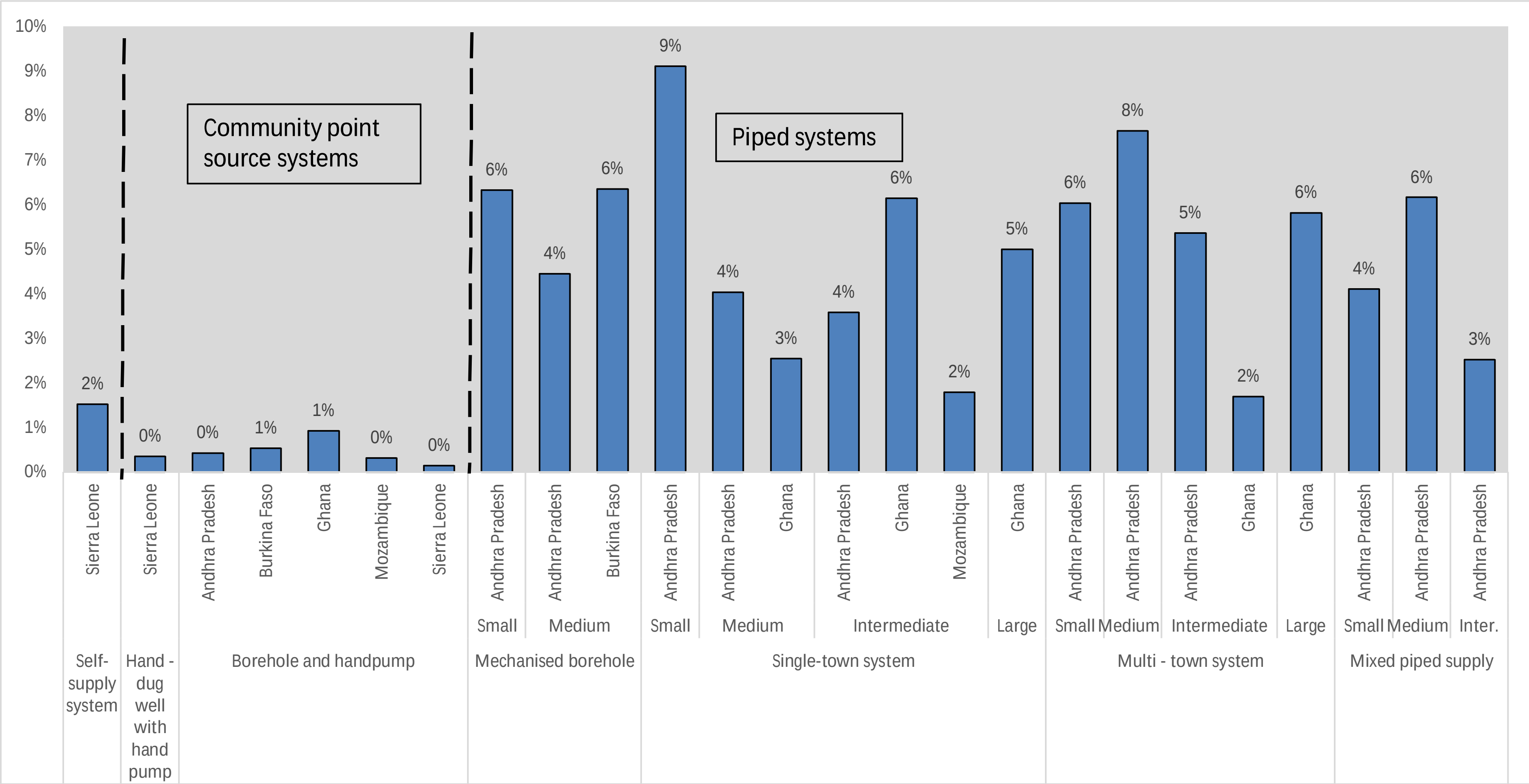


**Figure 5-22: Annual maintenance expenditure as a percentage of capital expenditure**



The levels of maintenance expenditure incurred tend to be higher in the African countries compared to Andhra Pradesh. For piped technologies of comparable size this difference tends to be between two and four times greater.

Table 5-8 shows the collated range of the current levels of maintenance expenditure for each technology. Two ranges are provided, the first showing the variation in mean expenditure for the systems sampled in Andhra Pradesh, and the second providing similar ranges for the African countries.

**Table 5-8: Maintenance expenditure cost ranges per technology**

| Water supply technology | Country where data was collected | Range of maintenance expenditure per person (all countries) | Range - maintenance expenditure per person (only African countries) |
|---|---|---|---|
| Self-supply | Sierra Leone | - | $1.21 |
| Hand-dug well with handpump | Sierra Leone | - | $0.08 |
| Borehole and handpump | Andhra Pradesh, Burkina Faso, Ghana, Mozambique, Sierra Leone | $0.09 | $0.06 - $0.37 |
| Mechanised borehole | Andhra Pradesh, Burkina Faso *(data not representative)* | $1.41 - $3.33 | - |
| Single-town system | Andhra Pradesh, Ghana, Mozambique | $1.19 - $7.87 | $1.93 - $5.67 |
| Multi-town system | Andhra Pradesh, Ghana | $1.91 - $2.82 | $4.82 |
| Mixed piped supply | Andhra Pradesh | $ 0.58 - $3.78 | - |

The existing relationships between the type of technology, capital expenditure, and maintenance expenditure are made clear in Figure 5-22. This demonstrates that the annual maintenance expenditure of the cheaper community point sources is between just 0% and 1% of the initial capital costs, considerably lower than the 2% - 9% annual expenditure on the more costly piped systems.

## 5.9 Expenditure and service levels comparison

This sub-section compares the mean capital and recurrent expenditure values recoded to the percentage of users receiving a “basic” water service for each technology type without differentiating between system size (Figure 5-23 and Figure 5-24).

The most striking finding from collating this data is that for nearly all technologies across the five countries, less than 50% of system users are achieving a “basic” level of water service. The capital-intensive nature of water supply means that these low levels of service are coming at a very high financial cost. This substantiates the contention that despite widespread increases in coverage, poor service delivery to users means a considerable amount of this investment is effectively being wasted and in terms of welfare economics reflects poor technical and productive efficiency.

Results from the African countries indicate that users of piped schemes do achieve higher levels of service (between an 18% and 44% increase in those achieving a “basic” service) than users of boreholes with handpumps, but this is coming at a five and eight fold increase in per person capital expenditure, and well over a thirty fold increase in maintenance expenditure per person, per year.

In Andhra Pradesh, there is no clear relationship between supply technology accessed, the levels of expenditure and the level of service achieved by users. Indeed borehole and handpump systems are actually delivering marginally higher levels of “basic” service than some of the much higher cost piped systems. However the complexity of how water services are delivered and accessed in Andhra Pradesh precludes simple conclusions on the relative cost effectiveness of different technologies. The service delivery reality in Andhra Pradesh is that resident’s access water from multiple informal and formal water sources at different times of the day and for different purposes. Service level analysis in these showed that many of these technologies are very unreliable but despite this, households are able to continue to access sufficient quantities of water. This highlights the resilience built into the service due to the large amount of water supply infrastructure available at community and household level[31]. In

[31] Household water supply systems are common in Andhra Pradesh. Data on these systems was collected but have not been included in this comparative study

constructing multiple, overlapping, but ultimately poorly performing water supply systems, service is cost inefficient and it is likely that better planning, and maintenance of water supply systems would lead to a reduction in overall expenditure and more reliable service delivery.

With the exception of self-supply systems, all technologies encountered major reliability problems. Most of the borehole and piped systems sampled were found to be non-functional for more than 12 days per year and where disaggregated data was available for piped systems this demonstrated that most funds were being spent on staff salaries, with only a fraction spent on new components. This gives strong support to the notion that current levels of expenditure on minor maintenance and appropriate capital maintenance (currently standing at between 0% and 1% of capital expenditure for community point sources, and between 2% and 9% of capital expenditure for piped systems) are insufficient.

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**Figure 5-23: Percentage of people achieving a “basic” water service level and capital expenditure per user**

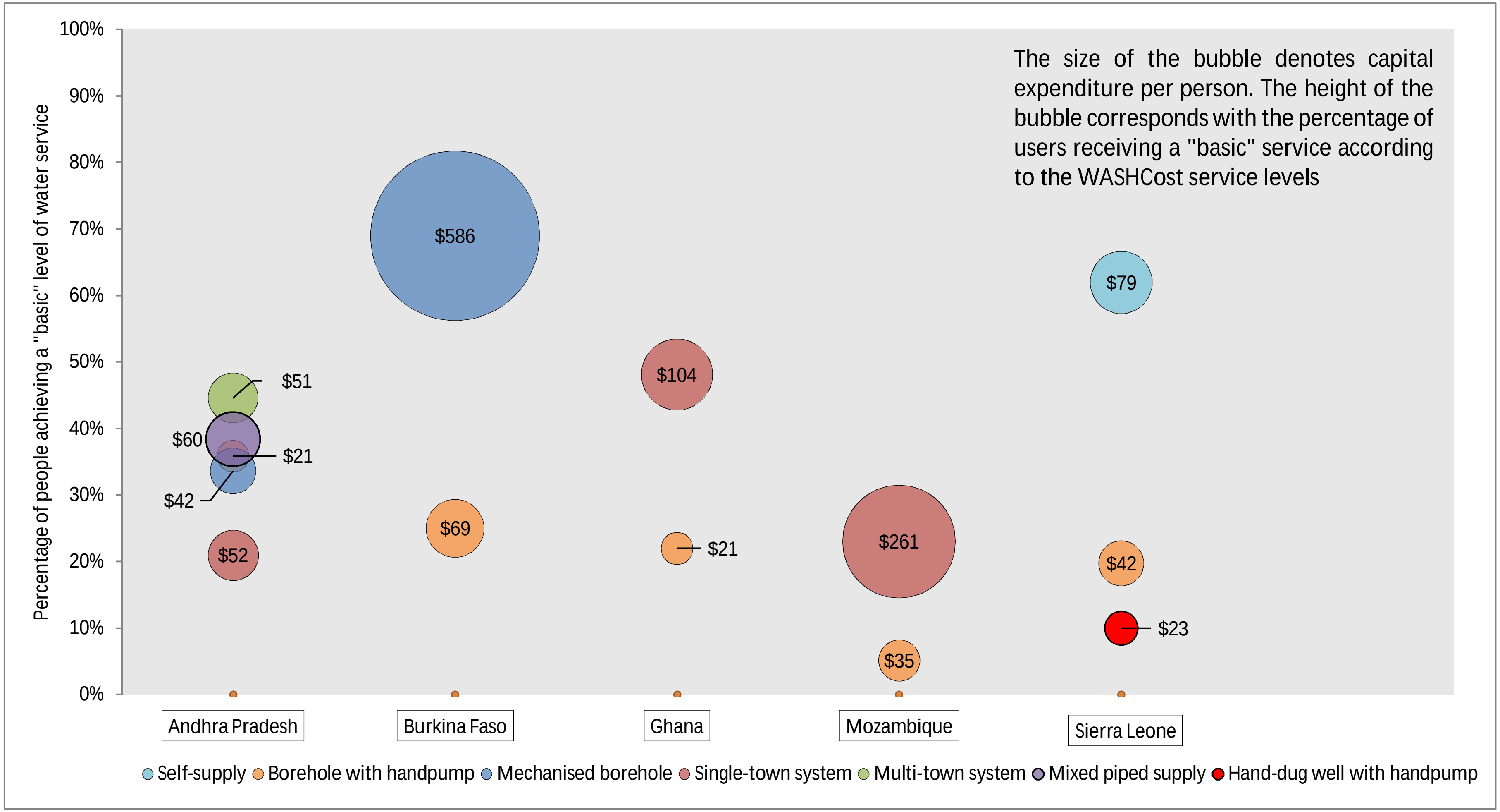
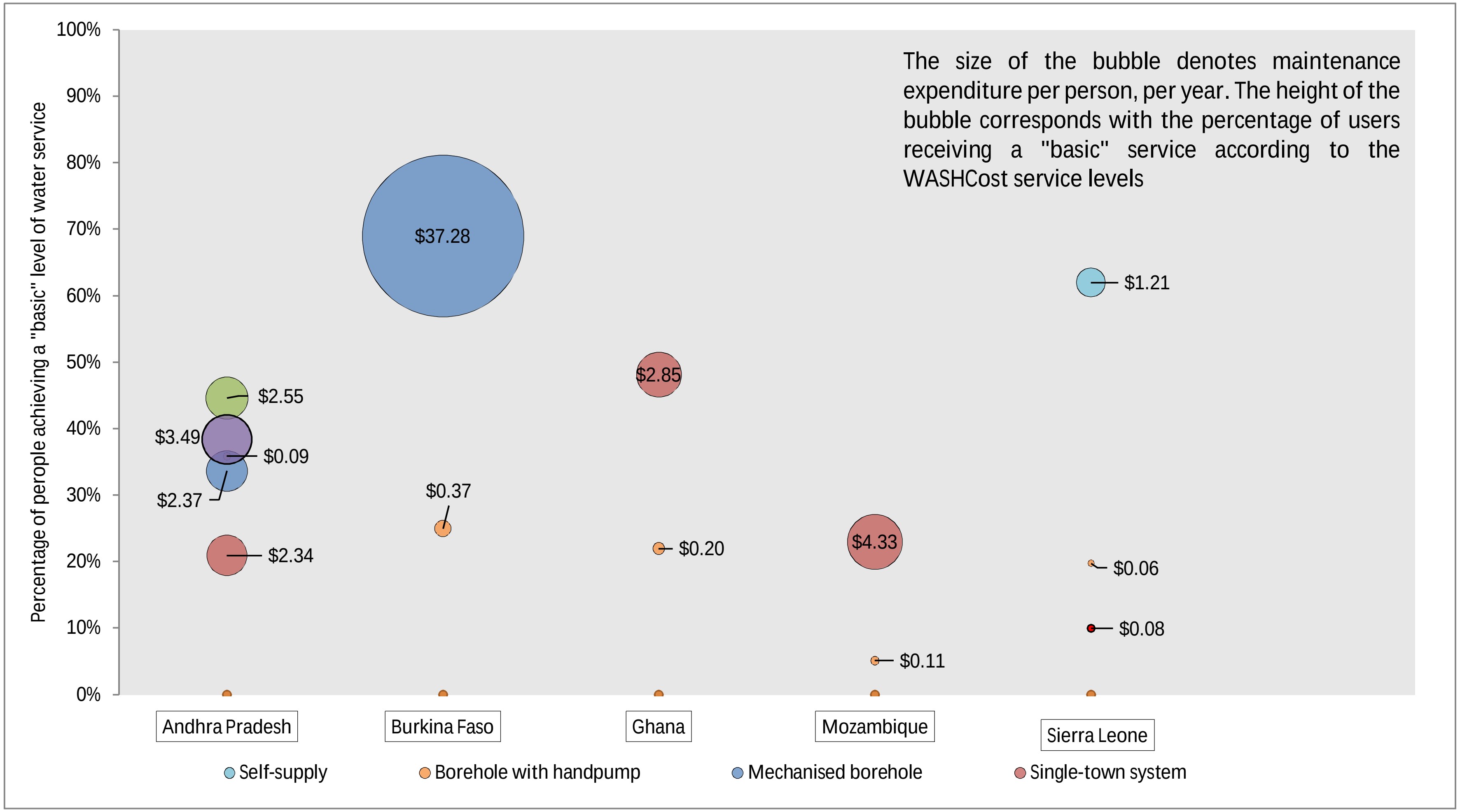


**Figure 5-24: Percentage of people achieving a "basic" water service level and maintenance expenditure per person, per year**



## 5.10 Normative expenditure to sustain water systems

The final component of this chapter addresses research objective 2.1 and seeks to provide a general assessment of the necessary expenditure required to sustain water systems based on this historical analysis of WASHCost data.

The low levels of service achieved, and particularly the extended periods where assets are not functioning, demonstrates that existing levels of annual maintenance expenditure of between 0% and 1% of the initial capital costs for community point sources and between 2% and 9% on piped systems, are insufficient to keep systems working. However, the low level of service across all systems provides few examples of good practice that can be used to calibrate better estimates of what this expenditure should be.

An understanding of the required (“normative”) CapManEx can be derived by depreciating the cost of an asset according to its capital cost (adjusted to current values) divided by its assumed life-span.

Empirical data from the five-country analysis has been used to better calibrate the normative CapManEx calculation as well as assumptions of asset life-spans (Table 5-9). The constituent parts of each water supply system have been disaggregated into short life assets (those with an estimated lifespan of ≤10 years), and long life assets (lifespan >10 years). The value of all components in each asset category are presented as a percentage of the overall capital cost of the technology. The normative CapManEx for each technology is calculated by dividing the proportional capital value of the short/long life assets by their respective assumed lifespans and summing them together.

**Table 5-9: Cost assumptions for the calculation of normative capital maintenance expenditure through linear depreciation**

<table>
<tr><th rowspan="2">Technology</th><th colspan="3">Short life assets</th><th colspan="3">Longer life assets</th></tr>
<tr><th>Main components</th><th>Percentage of total capital value</th><th>Assumed asset lifespan</th><th>Main components</th><th>Percentage of total capital value</th><th>Assumed asset lifespan</th></tr>
<tr><td>Self-supply</td><td>Water pump</td><td>40%*</td><td>4*</td><td>Well, storage tank</td><td>60%*</td><td>12</td></tr>
<tr><td>Hand-dug well with handpump</td><td>Handpump</td><td>15%*</td><td>10</td><td>Well</td><td>85%*</td><td>20</td></tr>
<tr><td>Borehole and handpump</td><td>Handpump</td><td>12%*</td><td>10*</td><td>Borehole</td><td>88%*</td><td>20</td></tr>
<tr><td>Mechanised borehole</td><td rowspan="4">Mechanised pumps, electrical components, standpipes, water meter, valves</td><td rowspan="4">Between 10% and 20%*</td><td>10</td><td rowspan="4">Transmission and distribution pipes, storage tank</td><td rowspan="4">Between 80% and 90%*</td><td>20</td></tr>
<tr><td>Single-town system</td><td>10</td><td>20</td></tr>
<tr><td>Multi-town system</td><td>10</td><td>20</td></tr>
<tr><td>Mixed piped supply</td><td>10</td><td>20</td></tr>
</table>

* indicates that assumption is underpinned by empirical data from the five country studies. All current cost capital expenditure values are a product of the analysis in this thesis.

In all cases there is a shortfall between existing capital maintenance expenditure and normative levels of capital maintenance expenditure (Table 5-10). For systems in Andhra Pradesh this analysis suggests that annual expenditure[32] would need to rise by between 1.3 and 3.0 times current levels to meet the normative requirement. Amongst the African countries the shortfall is even greater with normative values between five and six times greater than existing expenditure on piped systems and over forty times greater than existing expenditure on point source systems.

[32] Normative CapManEx provides an indicative estimate of the necessary annual budgetary amount to be set aside to cover future capital maintenance expenditure. Therefore this need not be a cost incurred every year but rather be documented as an accounting cost so funds are available when failure occurs.

**Table 5-10: Estimated shortfall in capital maintenance expenditure - "normative" CapManEx based on linear depreciation, "actual" CapManEx based on found values**

| Countries | Technology | Normative CapManEx per person, per year | Range normative CapManEx per person per year | Actual CapManEx per person per year | CapManEx surplus / shortfall per person, per year |
|---|---|---|---|---|---|
| Andhra Pradesh | Borehole and handpump (serving 300 people) | $0.4 | - | $0.0 | -$0.4 |
| | Mechanised borehole | $2.1 | $0.8 - $3.3 | $0.9 | -$1.2 (x 1.3) |
| | Single-town system | $4.2 | $1.6 - $9.1 | $1.3 | -$2.9 (x 2.2) |
| | Multi-town system | $4.0 | $1.2 - $5.9 | $1.0 | -$3.0 (x 3.0) |
| | Mixed piped supply | $3.1 | $0.9 -$6.7 | $1.3 | -$1.8 (x 1.3) |
| Burkina Faso, Ghana, Mozambique, and Sierra Leone | Self-supply (serving 10 people) | $10.1 | - | $0.0 | -$10.1 |
| | Hand-dug well with handpump (serving 300 people) | $1.3 | - | $0.0 | -$1.3 (x 42.4) |
| | Borehole and handpump (serving 300 people) | $2.2 | $1.8 - 2.5 | $0.0 | -$2.2 (x 54.0) |
| | Mechanised borehole | $5.5 | - | - | - |
| | Single-town system | $6.3 | $2.0 - $10.6 | $1.2 | -$5.1 (x 4.3) |
| | Multi-town system | $5.3 | $4.3 - $6.2 | $0.8 | -$4.6 (x 6.1) |

At this level of aggregation it has not been possible to adequately account for context specific socio-economic, and hydrogeological factors that may influence the levels of expenditure and levels of service. These context specific influences are investigated in the subsequent chapter 6 focussing on rural water services in Ghana.

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# 6 Detailed investigation of the costs of water services in rural Ghana

## 6.1 Scope of work

This chapter seeks a more detailed and context specific understanding of the sufficiency of existing levels of recurrent expenditure on rural water service delivery.

Findings in this chapter are founded upon a comprehensive inventory of rural water supply assets collected by the “Triple-S” project in two rural districts of Ghana namely the Akatsi District in the Volta region and East Gonja in the Northern region. This database includes a variety of management, maintenance, and functionality indicators first collected in 2011, and once again in 2013. In addition to this quantitative data, key informant interviews and focus group discussions undertaken at community, district, regional, and national levels provide a broader perspective of institutional and financing arrangements in rural Ghana.

The chapter is structured as follows. Initially it outlines the water service delivery context in rural Ghana, with specific reference to the roles and responsibilities of different agencies in the management and finance of these services. It then presents findings on the current status of asset management in rural Ghana through a review of the functionality, management, and current expenditure on rural water supply systems by communities, district assemblies, national government, and donors. As well as reporting findings on these indicators, this section also analyses the relationships between them, in particular how the management and financing of the water point impacts functionality.

The discussion section assesses the adequacy of the existing management practices and levels of expenditure to safeguard the functional sustainability of rural water supply assets. It also reflects on the challenges that different actors in the sector face in mobilising the necessary finance to maintain services. More broadly it examines whether the current policy guidelines shaping rural water management are realistic and sustainable given current practices and resource

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constraints found in Ghana which are also common to other lower-income contexts.

This chapter concludes with an indicative analysis, based on available evidence, on the level of recurrent expenditure required to improve the functional sustainability of rural water points.

## 6.2 Overview of case study districts

Akatsi District[33] is located in south-eastern part of Volta region in eastern Ghana Figure 6-1). As of 2011 the population of the district was estimated at 117,606 and had formal water coverage rates of 62% (Akatsi District Water and Sanitation Plan 2011-2014, Unpublished), slightly above the regional average. The district receives an average of 1,084 mm of rainfall per year spread between a wet season (May – October) and dry season (December – March).

East Gonja district is located at the southern edge of the Northern region of Ghana (Figure 6-1).The district is much larger than Akatsi and has dispersed population of 127,304 spread over nearly 11,000km$^2$. East Gonja has one major rainfall season between April and September; however the rains can often be irregular with total annual rainfall ranging between 1000 – 1500mm. About 59,813 representing 47% of the total population have access to water in the district (CWSA, 2011).

---

[33] In 2012 Akatsi district assembly was divided into Akatsi North (maintaining Akatsi town as the district capital) and Akatsi South (with Ave Dakpa as the district capital). The original baseline study by Triple-S was undertaken when Akatsi was a single district and therefore for the purpose of this report Akatsi refers to old district boundaries encompassing Akatsi North and South.

**Figure 6-1: Map of district boundaries in Ghana with case study districts highlighted**

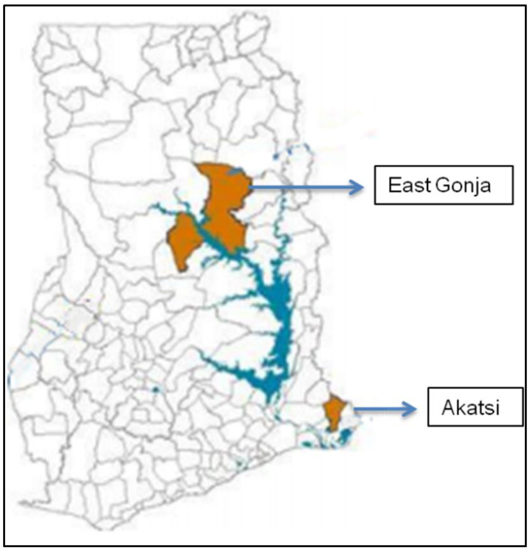


Table 6-1 summarises these characteristics of each district and shows that East Gonja is a much larger district than Akatsi and has lower water coverage rates and more challenging hydro-geological conditions – reflected in a lower borehole success rate.

**Table 6-1: Comparison of sample districts**

| **Characteristic** | **Akatsi District** | **East Gonja district** |
|---|---|---|
| Population | 117,606 | 127,304 |
| Area/km$^2$ | 1,077 | 10.787 |
| Population density (persons per km/sq.) | 115 | 13 |
| Mean household size | 4 | 4 |
| Average annual rainfall | 1084 mm | 1050 mm |
| Number of improved point sources | In 2011 = 249 | In 2011 = 122 |
| | In 2013 = 292 | In 2013 = 136 |
| Number of piped systems | 6 | 8 |
| Formal water coverage rates | 62% | 47% |

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| | | |
|---|---|---|
| Borehole success rate* | In Akatsi district, and in Volta region as a whole, boreholes tend to be fairly low yielding. Typical depth to the aquifer range for 45 – 60m. The typical success rate of borehole drilling is around 80%. | In the worst areas towards the north of the district success rates can be as low as 25%. 45% - 55% is typical across the district. |

Sources: District Water and Sanitation Plan - Akatsi District (2011); District Water and Sanitation Plan – East Gonja District (2011). *Information from interviews with hydro-geologists: Naa Dogoli (Volta region - Akatsi district), Mr Aduakye (Northern region - East Gonja district).

## 6.3 Management of rural water services in Ghana

### 6.3.1 Community responsibilities

In Ghana, rural water services are delivered under a Community Ownership and Management model (COM). The two most common COM models are Water and Sanitation (WATSAN) committee management in small communities and Water and Sanitation Development Boards (WSDBs) management in small towns. This case study is concerned with the management of water points in small communities and also therefore with the activities of the WATSAN committees.

Small communities are defined in national guidelines (CWSA, 2010) as having a population of between 75 and 2,000. The type of water system supply within each small community should be determined by population size and hydro-geological conditions, with supply options varying between a hand-dug well, a borehole with handpump, or a small piped system (Table 6-2).

**Table 6-2: Water supply options for small communities in Ghana**

| Community size | Guideline water supply option |
|---|---|
| 75-299 | A hand-dug well with a handpump is to serve a population of not more than 150. Where the construction of a hand-dug well is not feasible, a borehole fitted with a handpump shall be provided. |
| 300-1200 | A borehole with handpump is to serve a population of not than more than 300. |
| 1201- 2000 | A limited piped system based on a spring, groundwater or surface water source with a small transmission, storage and distribution network. |

Adapted from Community Water and Sanitation Agency (2010)

When a water system is constructed in a small community, the agency which constructed the system should ensure that a gender balanced community water and sanitation committee is set up to manage the system. According to national guidelines the community WATSAN committee must ensure the routine operation and maintenance of the water point and in the event of minor breakdown should engage and finance the services of an area mechanic to undertake necessary repairs. The WATSAN committee is also responsible for setting and collecting tariffs from other community members .Ideally this tariff should be volumetric and collected by water point vendors, this method is known locally as “pay as you fetch” (CWSA, 2010).

To put this in to context, the model of community ownership and management practiced in Ghana is well aligned with what is considered sector best practice. The model includes:

- An inclusive, gender balanced and representative community based organisation managing the system;
- Communities having a measure of control over system design and assuming responsibility for operation and maintenance;
- Communities free to make independent management decisions (World Bank, 1998).

### 6.3.2 Community Water and Sanitation Agency responsibilities

Another key actor under the COM model is the Community Water and Sanitation Agency (CWSA). The CWSA operates at national and regional levels and is responsible for facilitating the provision of safe and reliable water services to rural areas. CWSA often takes the lead in developing policies and guidelines for the governance of rural water systems but is also responsible for a range of sector activities including: the training and capacity building of District Assembly staff and WATSAN committees; direct technical and human resource assistance in planning and implementing water supply projects; and assisting in the monitoring of system performance (IRC and Aguaconsult, 2011).

### 6.3.3 District Assembly responsibilities

The local District Assembly (DA) is the legal owner of formal water assets within a district. Once constructed, assets are given in trust to community WATSAN’s for management, although the District Assembly retains the overall responsibility for ensuring that water rural systems continue to function.

Within each District Assembly there is a District Water and Sanitation Team (DWST) who are responsible for providing direct support to WATSAN committees, including advice on technical and management issues such as facilitation) or repairs, tariff setting and collection as well as oversight in the form of the periodic financial reviews and auditing of WATSAN accounts (CWSA, 2010). Importantly they are not responsible for financing of ongoing operation and maintenance, but may provide financial assistance in cases where the costs of repairs go beyond the ability of communities to pay them.

Updated information on community water services and management should be entered by a DWST member into the District Monitoring and Evaluation System (DiMES) software package hosted within the DWST office. DiMES is designed as a decision-support tool that receives information and is able to analyse this and provide status reports on system performance and WATSAN management that can inform quarterly action plans that focus the work of the DWSTs (CWSA 2009).

In theory DiMES should be updated as part of periodic monitoring at the district level. Information from each district assembly are collated at regional CWSA level and then once again at CWSA head office for a national overview. The compiled data emanating from DiMES has a direct impact on the Strategic Investment Plan developed by CWSA head office. Collating this data at different governance levels facilitates strategic planning and equitable investments based on areas of greatest need. As explained in the DiMES user manual:

*DiMES is structured in such a way that it can support all the administrative structures of the country, where data could be gathered and entered directly at the point of data generation and distributed to all other relevant and respondent administrative units, and used for all the functionality of the system, namely, planning for investments, management and monitoring and evaluation* (CWSA, 2009).

The District Assembly also retains some responsibility for the rehabilitation of community water systems. National guidelines state that the “major repairs or borehole rehabilitation outside the technical and financial capacity of the community shall be undertaken with the assistance of the DA” (CWSA, 2010). A definition of what is “outside the capacity of the community” is not provided and therefore interventions by the DA tend to be decided on case by case basis.

### 6.3.4 Donor responsibilities

Donors play a significant role in funding rural water services. In small communities, as with much of rural Ghana, capital investments are largely financed by international donor organisations. According to CWSA (2007) approximately 88% of the capital costs of WASH facilities in 2006 were sourced from international partners.

### 6.3.5 Summary of roles and responsibilities

The preceding overview shows that under the community ownership and management approach the prescribed responsibilities for asset management (i.e. those activities associated with constructing, maintaining, renewing, and monitoring assets) are fragmented amongst number of different stakeholders – these responsibilities are summarised in Table 6-3. Within this normative framework the financing of ongoing costs of asset maintenance should be covered by a combination of community tariffs paid directly to the WATSAN, or domestic taxes allocated to the District Assembly or Community Water and Sanitation Agency.

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**Table 6-3: Who should pay: Life-cycle costs under community ownership and management**

| Life-cycle cost component | Activities | Responsible organization | Fund mobilization |
|---|---|---|---|
| Capital expenditure hardware | Construction of new water points. | National and international donors and the government of Ghana. | Transfers & Taxes<br>At present 88% of all new capital investment is currently financed by donor organisations – and this is accepted at all levels. Occasionally new systems are financed entirely by government agencies themselves. |
| Capital expenditure software | The costs of community mobilization and training of the WATSAN committee. | National and international donors and the government of Ghana. | Transfers & Taxes<br>These are included as part of the hardware contract. |
| Operational and minor maintenance expenditure | Greasing, inspection, water quality testing and minor maintenance | Communities | Tariffs<br>Ongoing community tariffs or ad-hoc revenue mobilization. |
| Capital maintenance expenditure (hardware) | Rehabilitation or repair of the hand-pump or borehole after major breakdown | Communities & District Assemblies | Taxes & Tariffs<br>When the level of the expenditure goes beyond the capacity of the community the DA should meet the costs of rehabilitation. |
| Capital maintenance expenditure (software) | Occasional refresher training of WATSAN teams. | CWSA & District Assemblies | Taxes & Transfers<br>Through central government grants and internally generated income. |
| Expenditure on direct support | Technical and managerial performance monitoring, financial auditing, and technical support and backstopping. | CWSA & District Assemblies: | Taxes<br>Through central government grants and internally generated income. |

This chapter now turns to examine how effective this institutional and management model is in ensuring the effective management of rural assets, and assess the extent to which these prescribed roles and responsibilities are being fulfilled.

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## 6.4 Current status of asset management in Rural Ghana

### 6.4.1 Water point functionality

The asset inventory data from 2011 shows that between 26% of point source systems in Akatsi are completely "broken down" compared to 29% in East Gonja[34] (Table 6-4). By 2013 the percentage of broken down systems has reduced to 16% in Akatsi and has risen to 31% in East Gonja. In addition to broken down systems, a further 7% of systems in 2011 and 17% of systems in 2013 systems were "non-functional". A marginally higher percentage of partially functional or fully functional systems were found in Akatsi (67% in 2011, 66% in 2013) in comparison to East Gonja (64% in 2011; 56% in 2013.

Across both districts 35% of water points were found to be either broken down or non-functional.

**Table 6-4: Water point functionality in Akatsi and East Gonja districts**

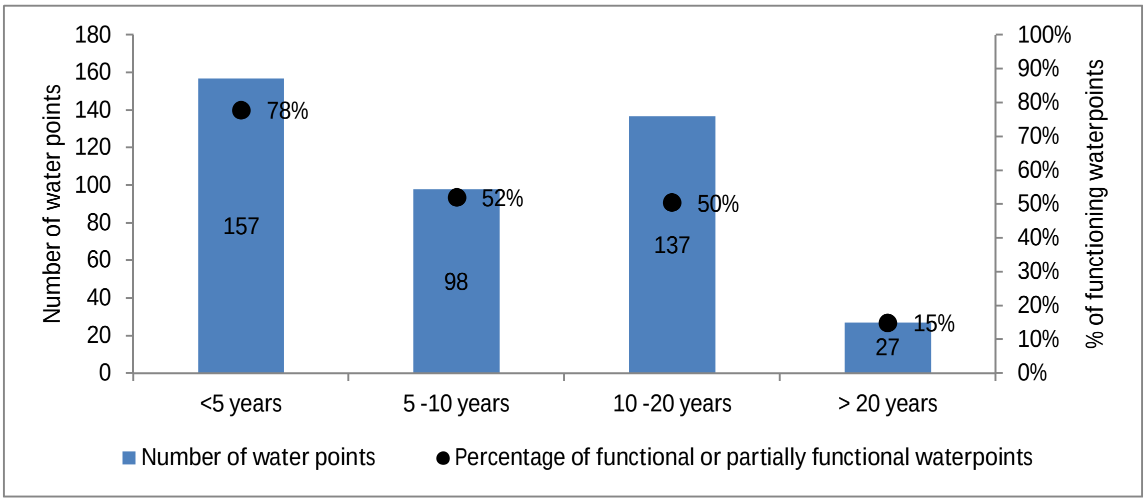
| Year of data collection | District | Number of water points | Broken down | Non functional | Partially functional | Functional |
|---|---|---|---|---|---|---|
| 2011 | Akatsi | 249 | 26% | 7% | 48% | 19% |
| | East Gonja | 122 | 29% | 7% | 22% | 42% |
| 2013 | Akatsi | 292 | 16% | 17% | 39% | 27% |
| | East Gonja | 136 | 31% | 14% | 18% | 38% |
| Total | | 799 | 24% | 12% | 36% | 29% |

The age profile of all the assets in 2013 are shown in Figure 6-2 alongside the respective percentage of functional or partially functional assets by age classification – excluding those water points that have been rehabilitated.

[34] Water point functionality was determined by the stroke and leakage tests. The stoke test measures the number of strokes of a handpump to fill a size 34 bucket (20 litres) within 1 minute. To pass the stoke test the bucket must be filled by no more than 40 strokes for the Afridev and Ghana Modified India Mark II handpumps and no more than 30 strokes for Nira AF-85 hand pumps. For the leakage test, pumping is resumed after 5 minutes rest following the stroke test. If water flows from the hand pump within 5 strokes, the pump has passed the leakage test. If the borehole with handpump fails both of these tests it is classed as "non-functional", if it fails one of these test it is classed as "partially functional" and if it passes both it is classed as "functional".

Slightly less than two-thirds (61%) of all the point sources were constructed within the last 10 years emphasising the rapid recent growth in rural water coverage. A Pearson's Chi-Squared analysis of the two categorical variables of system age versus functionality was undertaken[35]. This test shows a significant association between functionality status and system age, $X^2$ (3, N = 428) =51, p<0.001. There are two points of clear difference. After five years of operation the functionality of these systems drops reduces from by just over 25% (78% to 52%). Systems between 5 and 20 years old have similar functionality rates, but after 20 years functionality once again to 15%.

**Figure 6-2: Water point age profile and functionality (2013 data)**




## 6.4.2 Impact of non-functionality

The impact of poor functionality on service delivery is marked. Nearly half (48%) of the rural communities in the sample only have access to a single formal water source. There is therefore no supply redundancy in these communities so if the system breaks down the community members will necessarily revert to informal sources[36].

According to the 2013 inventory, the failure of community water points means 63 communities in Akatsi and 30 communities in East Gonja no longer have access

35 For this analysis the functionality status was dichotomised between functional systems (those classified as functional or partially functional systems) and non-functional systems (those classified as broken down and non-functional).
36 Assuming no household self-supply systems are in place.

to an improved water supply - this affects 30,180 people (22% of the combined district population).

### 6.4.3 Water point management indicators

The management of communities is evaluated according to a series of indicators captured in the water asset inventory - these indicators are described in Table 6-5.

For each indicator data was captured in both 2011 and 2013 and results are reported as average values across both these years. The exception to this is the analysis of rehabilitations which is based on the most recent data (2013) to avoid double counting.

**Table 6-5: Available information on water point management and maintenance**

| Question | Possible answers | Data used for analysis | Comments |
|---|---|---|---|
| Are water points being managed by Water and Sanitation Committee? | Yes, No, No data | Combined inventory data from 2011 & 2013 | This indicator is captured at community level. The WATSAN is assumed to manage all water points in the community unless expressly stated in the inventory. |
| Does the community charge a tariff? | "Pay as you fetch", Monthly, No tariff, No data | Combined inventory data from 2011 & 2013 | This indicator is captured at community level. The same tariff structure is assumed to be in place for all community point sources unless expressly stated. |
| Has the community received a visit from a district assembly representative in the past year? | Yes, No, No data | Combined inventory data from 2011 & 2013 | This indicator is captured at community level and is reported as the percentage of communities visited not water points visited. |
| Does the community undertake periodic/preventative maintenance[37]? | Yes, No, No data | Combined inventory data from 2011 & 2013 | Captured at community level. Instances of periodic/preventative maintenance is classified as and operational expenditure. |

[37] The Triple - S data collection protocol defined periodic/preventative maintenance as regular and systematic activities undertaken by a pump caretaker or area mechanic to keep the system working – this includes the greasing of the handpump chain and replacement of small fast wearing parts such as nuts, bolts and cup leathers.

| | | | |
|---|---|---|---|
| Does the community undertake corrective maintenance[38]? | Yes, No, No data | Combined inventory data from 2011 & 2013 | This is defined as an operational cost. The actual repairs undertaken are not specified. Data collection aimed to capture small scale repairs as "corrective maintenance" and major repairs as "rehabilitation" (see footnote 38). |
| How much did the community spend on maintenance in the last year? | Numeric | Combined inventory data from 2011 & 2013 | This is captured at community level - expenditure per water point is calculated by taking annual expenditure divided by the number of water points in the community. Expenditure was not subdivided between operation and capital maintenance expenditure. |
| If the system is non-functional why has it not been repaired? | String | Combined inventory data from 2011 & 2013 | |
| Has the water point rehabilitated? | Yes, No, No data | 2013 inventory data only | This is defined as a capital maintenance cost. |
| Which organisation financed the rehabilitation? | String | | |

In addition to the quantitative indicators captured in the asset inventory, subsequent sections also report on qualitative evidence collected by the researcher during community field visits, focus groups discussions, and key informant interview.

### 6.4.4 Water point management practices

In both districts more than two-thirds (68%) of water-points are being managed by a Water and Sanitation committees (Table 6-6). The percentage of managed water points is marginally higher for those in East Gonja (72%) than Akatsi (67%).

The collated data shows that some form of tariff - either a volumetric "pay as you fetch" tariff or a flat rate monthly fee - is being levied at 72% of water points. In Akatsi district, a tariff is charged at 87% of rural water points compared to just

[38] Corrective maintenance was defined as expenditure in restoring the functionality of broken down systems. Corrective maintenance values were designed to be captured separately to instances of major repair and rehabilitation however as the inventory did not specify the details of the breakdown or the type of maintenance that took place there is some uncertainty over whether these values relate to operational, or capital maintenance expenditures.

36% in East Gonja. Comparison using a chi-squared test for independence (adjusted for Yates continuity correction) shows there is a significant relationship between the district (Akatsi and East Gonja) and whether a tariff is levied at each water point, $X^2$ (1, N = 535) =267, p<0.001).

Similarly community monitoring by the District Assembly is more common in Akatsi (87% have been visited in the last year) compared to 29% in East Gonja, this relationship is also significant, $X^2$ (1, N = 174) =85, p<0.001). The structure of the available data did not allow for an ordinal regression analysis assessing the impact of community monitoring on tariff setting. Nevertheless the higher incidence of both community monitoring and the collection of tariffs in Akatsi district (in comparison to East Gonja) does suggest a relationship.

**Table 6-6: Rural community management indicators**

| **Indicator** | **Akatsi** | **East Gonja** | **Total** |
|---|---|---|---|
| *WATSAN management* | | | |
| Percentage of communities with a functioning water and sanitation committee | 67% (n=221) | 72% (n=116) | 68% (n=337) |
| *Tariff setting* | | | |
| No tariff | 12% (n=45) | 64% (n=107) | 28% (n=152) |
| Monthly flat rate tariff | 18% (n=67) | 11% (n=19) | 16% (n=86) |
| Volumetric (“pay as you fetch”) tariff | 69% (n=255) | 25% (n=42) | 56% (n=297) |
| *Support to communities* | | | |
| Percentage of communities visited by a representative of the district assembly in the last year | 87% (n=116) | 29% (n=12) | 74% (n=128) |

Note: The total number of data points (the *n* values) vary for each question depending on either a) variations in the number of valid responses captured in the asset inventory or b) whether the unit of analysis is the water point, or the community, as one community may contain a number of different water points and these can be managed in different ways.

Separate comparisons were done between the above water management indicators and the level of water point functionality (Table 6-7). In each case when the CWSA guidelines were adhered to (i.e. a WATSAN committee was in place, a tariff was being levied, and the district assembly was regularly visiting the community) water point functionality improved. The biggest differences in

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functionality are found between the water points where either a monthly tariff (71% functionality) or a volumetric “pay as you fetch” tariff (69% functionality) is levied and those where there is no tariff levied (51% functionality, a difference of between 18% and 20%).

It is likely that these indicators are correlated, in that high degrees of district support are likely to impact whether a WATSAN committee is in place and also whether a tariff is being levied. It has not been possible in this analysis to statistically assess the cumulative effect of these indicators on functionality, or the degree of collinearity between indicators.

**Table 6-7: Percentage of functioning water points under different tariff structures**

| Indicator type | Response | Percentage of water points that are functional or partially functional (average of 2011 and 2013 data) |
|---|---|---|
| Is there a functioning WATSAN committee? | Yes | 67% |
| | No | 57% |
| Is a tariff being levied? | No fixed tariff | 51% |
| | Monthly levy | 71% |
| | “Pay as you fetch” | 69% |
| Was the community visited in the last year? | Yes | 68% |
| | No | 56% |

### 6.4.5 Expenditure on operation and minor maintenance

The annual expenditure on maintenance (including both periodic and corrective maintenance) for each water point in each district is outlined in Table 6-8[39]. The median expenditure per water-point in Akatsi district was $15.2 (mean $28.4), which is marginally higher than the $12.2 (mean $21.8) spent in East Gonja. Across all communities, the median expenditure is $14.4 ($26.2). The data was not normally distributed and there was considerable variability in the costs incurred from system.

[39] In some communities both preventative maintenance and corrective maintenance had been undertaken but no cost was incurred by the community. In these cases the repair of the system may have been financed by a private individual or outside organisation and not been captured in the inventory; alternatively the workmanship may have been undertaken for free. There is no way to verify the nature of this zero cost maintenance and these have been excluded from the analysis.

**Table 6-8: Annual expenditure on maintenance per water point in Akatsi and East Gonja**

| Descriptive Statistics | Nº of water points t | Mean | Median | 25th percentile | 75th percentile | Standard deviation |
|---|---|---|---|---|---|---|
| Akatsi | 269 | $28.4 | $15.2 | $2.5 | $39.0 | 36.0 |
| East Gonja | 133 | $21.8 | $12.2 | $3.4 | $27.1 | 36.7 |
| Total | 402 | $26.2 | $14.4 | $3.0 | $34.3 | 36.3 |

The available data was not sufficiently detailed to disaggregate the costs of specific maintenance activities. However the approach that the community has taken to system maintenance was captured, and is classified as follows:

- **No maintenance:** There is no evidence that the community has undertaken any form of periodic or corrective maintenance of the water point system. The absence of corrective maintenance may be because the system is deemed to be performing to a satisfactory level. Alternatively there may be problems with functionality but the community has not mobilised resources to address these.
- **Corrective maintenance only:** There are records to show that the community has previously financed the repair of the water system when it has failed ("fix on failure"). However the community has not financed any ongoing or periodic maintenance of the system.
- **Periodic maintenance only:** Records show that the community has financed some form of ongoing or periodic maintenance of the system, but corrective maintenance has not been undertaken. Sometimes this work is carried out by a pump caretaker, and other times by an area mechanic. These activities may involve the simple greasing of the chain and repair of fast wearing parts, but can involve engaging an area mechanic to open inspect handpump components. The precise activities associated with periodic maintenance were not captured in the asset inventory.
- **Periodic and corrective maintenance:** Evidence of both periodic and corrective maintenance is captured in community records.

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The expenditure per water points under these different maintenance scenarios are shown in Figure 6-3. In 20% of cases no periodic or corrective maintenance has been undertaken and correspondingly recurrent expenditure values are very low (median $0.0; mean $1.4). In around half of cases (49%) both periodic and corrective maintenance were performed, “periodic maintenance only” was undertaken in 18% of cases and “corrective maintenance only: in 14% of cases.

The Kruskal-Wallis test was used to assess the differences in median expenditure under different maintenance scenarios. Costs varied significantly between each scenario (p=0.00). Specifically the expenditure on “corrective maintenance only” (median $25.4) and corrective and periodic maintenance (median $24.6) are significantly higher, at the Bonferroni adjusted value of p=0.008, than those who conduct “periodic maintenance only” (median $11.3). The ranges of expenditure with 95% confidence intervals are shown in Figure 6-3.

**Figure 6-3: Median annual expenditure on water-point maintenance with 95% confidence intervals**

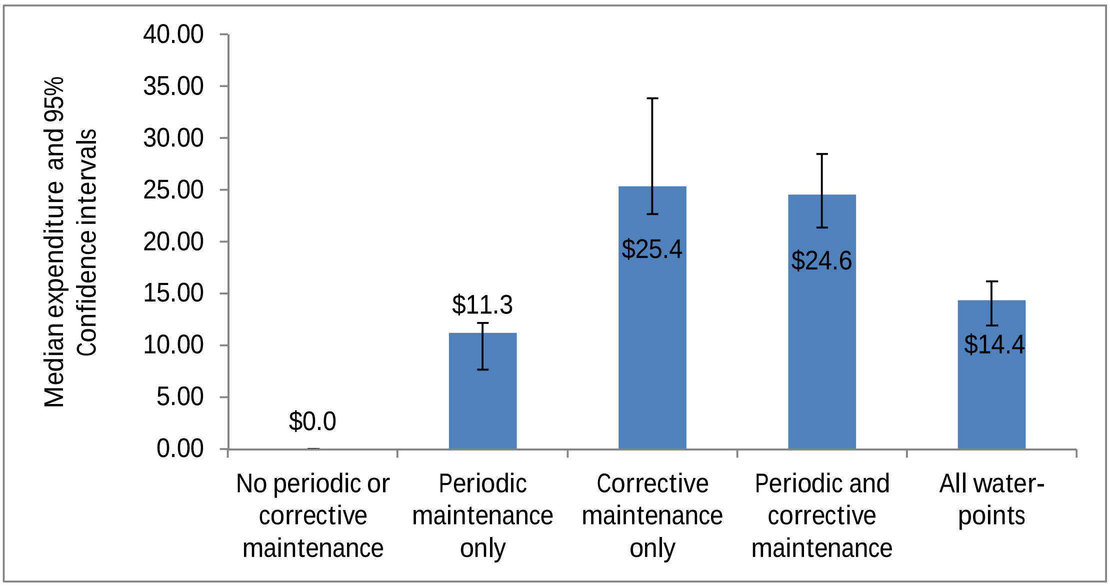


**Table 6-9: Descriptive statistics of maintenance expenditure in Akatsi and East Gonja districts**

| Descriptive statistics | No maintenance | Corrective only | Periodic only | Periodic and corrective | All water points |
|---|---|---|---|---|---|
| count | 79 | 55 | 72 | 196 | 402 |

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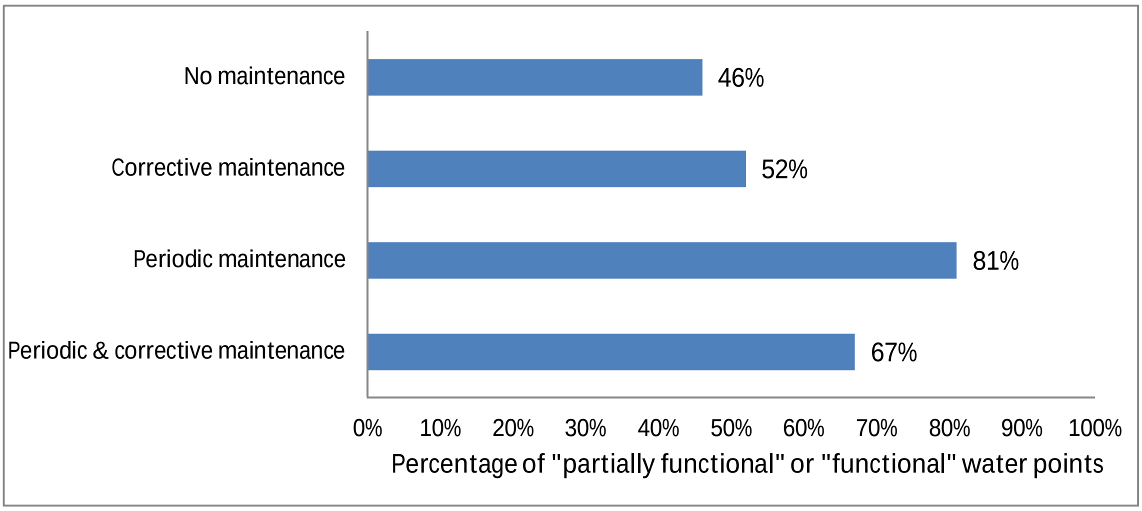
| | | | | | |
|---|---|---|---|---|---|
| min | $0.00 | $3.55 | $0.76 | $0.63 | $0.00 |
| max | $50.76 | $101.52 | $204.13 | $314.72 | $314.72 |
| q1 | $0.00 | $20.30 | $2.54 | $12.18 | $3.13 |
| Median | $0.00 | $25.38 | $11.27 | $24.57 | $14.37 |
| q3 | $0.00 | $41.62 | $20.43 | $42.17 | $34.16 |
| Mean | $1.51 | $33.99 | $16.53 | $37.06 | $26.12 |
| StDev | $6.50 | $25.84 | $26.72 | $42.73 | $36.30 |

This analysis demonstrates that the expenditure on repairing a broken down system ("corrective maintenance only") are significantly higher than the costs of periodically maintaining the system. Comparison of mean and median values suggests that the costs of "corrective maintenance only" as approximately double those of "periodic maintenance only".

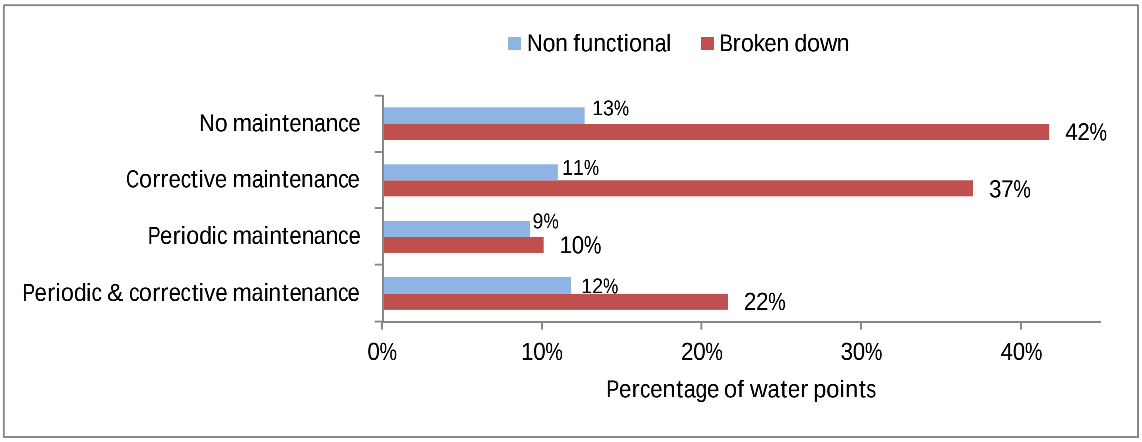
Figure 6-4 shows the percentage of functional and partially functional water points that are found under each maintenance scenario. When no maintenance is taking place, less than half (46%) of water points were found to be functioning adequately. When a corrective maintenance only strategy was adopted, functionality rates rose slightly to 52%. Water points that were maintained periodically, but had not been subject to corrective maintenance, demonstrated the highest rates or functionality at (81%), whereas other systems incurring both types of maintenance showed slightly lower levels of functionality at 67%.

**Figure 6-4: Percentage of partially or fully functioning water points under different maintenance strategies**



The reasons for communities adopting specific approaches to maintenance were not captured systematically. In the “no maintenance” scenario, the high rates of “broken down” or “non-functional” systems (the percentage breakdown of these are presented in Figure 6-5) suggest that the communities in question do not have the willingness or ability to finance a local area mechanic to undertake repairs. In some cases this may be because the breakdown is known or thought to be related to fundamental problems of yield related to local hydro-geology, however the higher rates of functionalities amongst alternative maintenance scenario’s suggest many repairs may be within the means, if not the willingness, of a community to address. This is suggestive that in some communities there is not sufficient community demand for these types of point sources – hand-dug well with handpump, or borehole with handpump.

**Figure 6-5: Percentage of "broken down" or "non-functional" water points per maintenance scenario**




Ensuring periodic maintenance means the community – typically through the local WATSAN committee – ensures the ongoing maintenance of water points through the replacement of fast wearing parts, the greasing of essential components, and/or the engagement of an area mechanic to inspect the systems. The data shows that the typical costs of undertaking this maintenance are relatively low (median $11.3 per system per year) as captured in the “periodic maintenance only” category. The communities where periodic maintenance takes place exhibit the highest levels of water point functionality (Table 6-10). Overall functionality rates increase markedly – by between 16% and 32% - if a periodic

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maintenance regime is put in place, suggesting improvements in the resilience and therefore the life-span of water points.

**Table 6-10: Percentage of functioning water points under different approaches to periodic maintenance**

| Maintenance strategy | Percentage of water points that are functional or partially functional | |
|---|---|---|
| | **2011** | **2013** |
| No periodic maintenance | 41% (n=64) | 54% (n=101) |
| Some periodic maintenance | 73% (n=190) | 70% (n=180) |

However once a system starts to fail and corrective maintenance is required, communities find it much more difficult to sustain levels of water point functionality.

If a water point source was non-functional the asset inventory captured the reasons why system had not been repaired. By far the most common response (68% of answers) was that the community did not have enough, or couldn't raise sufficient funds to undertake repairs. The next most frequent response, other than "don't know" (10%), was that the community couldn't contact an area mechanic to undertake the repair (8%) and that breakdown was because the water point was very low yielding and could not repaired (8%) (Table 6-11).

**Table 6-11: The reasons for not repairing non-functional water points**

| Reason system was not repaired | Percentage of non-functional water points |
|---|---:|
| Lack of funds | 68% |
| Couldn't contact an area mechanic | 8% |
| Lack of spare parts | 5% |
| Low yield | 8% |
| Other | 1% |
| Don't know | 10% |

The information collected from community visits and extracted from the asset inventory suggests reasons why communities may feel that they cannot afford the costs of system repair:

- Some water point failures may be very significant and require rehabilitation which may be very costly. The average costs of the system rehabilitation are laid out in section 6.4.5, but can be expensive running into the hundreds of dollars.
- If alternative functioning formal sources are available in the community, or traditional informal sources are readily available (such as in the rainy season), the effective demand for a functioning water points may be temporarily reduced and repair of the broken down system postponed. Community records documenting seasonal fluctuations of community demand are detailed in Appendix F.2.
- There is not a functioning WATSAN that is able to co-ordinate funds mobilisation from community members (stated in both districts). Simple financial analysis of potential revenues from a "pay as you fetch" tariff suggests that even in a low usage scenario - just 50 users each collecting a 22 litre bucket per day, at the lowest found tariff of $0.1 per bucket, and including a fee for a water vendor – the committee should still accrue $146 per year, over ten times existing maintenance expenditure (see G.2 for full details).

In these cases instead of the system being fixed at the point of failure, there is often a considerable time lag between failure and eventual repair – a "slow response fix on failure".

In the addition to these costs of ongoing, relatively frequent and relatively minor maintenance, data has also been analysed on the frequency of costs of water point rehabilitations – termed capital maintenance expenditure.

### 6.4.6 Expenditure on capital maintenance

Only 6% (n=36) of water-points in the sample have been rehabilitated at any point in time. Of those that have been rehabilitated 22% have reverted back to being non-functional. Comparing the data from the 2011 and 2013 inventories shows that in the 18 months between the two surveys only one (1) water-point was rehabilitated. Table 6-12 details the organisations which financed the water point rehabilitation. Out of the 36 rehabilitations just two have been financed by either

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the Community or the District Assembly. The majority 22 (62%) are financed from either international NGOs or religious organisations.

**Table 6-12: Organisations financing water point rehabilitations**

| Financing organisation | Number of rehabilitations |
|---|---|
| Community | 1 (3%) |
| District assembly | 1 (3%) |
| Government | 5 (14%) |
| International NGO | 12 (33%) |
| Private finance | 1 (3%) |
| Religious organisation | 10 (28%) |
| Unknown | 6 (17%) |

Specific data on the actual costs of each of the 36 rehabilitations were not available in either the asset inventory database or from community records. The estimated costs of rehabilitation came from an unpublished study by the Akatsi DWST assessing both the type of breakdown and cost of repair of 66 failed water points.

The DWST study found that in all cases the breakdown related to a fault with the handpump, as opposed to a failure of the water source or of the integrity of the borehole or hand-dug well. Across the 66 data points the average estimated cost of rehabilitation was $194, inclusive of materials and labour. This figure should be treated as indicative of the scale of the expenditure required to rehabilitate a handpump although specific rehabilitation costs are likely to vary considerably depending on the cause of breakdown. By way of comparison the estimated rehabilitation costs is somewhat less that estimated cost of between $465 to $723 to replace a handpump system (Bill of quantities – CWSA head office).

The DWST study shows that many of the issues with functionality related to the mechanical breakdown of a system component(s), and are therefore repairable given the sufficient allocation of financial resources. The infrequency of rehabilitations however demonstrates that much of this financing is not forthcoming.

Key informant interviews with community, district, and CWSA representatives were undertaken to better understand which organisations should be financing rehabilitation, and the factors which are constraining investment in system maintenance and rehabilitation.

### 6.4.7 Perspectives on financing capital maintenance expenditure

Within the regional CWSA offices the majority (4/5) of respondents were emphatic that responsibility for all water point maintenance is part and parcel of the social contract that communities undertake when systems are entrusted to them. Community WATSAN committees should be provided with management and technical support by district assembly and CWSA representatives, but ultimately the financial burden of all maintenance, rehabilitation and replacement costs lie with community members.

In contrast within District Water and Sanitation Teams, all respondents thought that although communities should cover operational and minor maintenance costs, they should receive some support from either the District Assembly or donors to cover the costs of major repairs as these were often beyond the ability of communities to pay.

Only one of the communities visited accepted they were responsible for financing both maintenance and eventual rehabilitation. The remaining six communities expected assistance from either district or donors to finance repairs.

There is a clear difference between perspective of employees within the Community Water and Sanitation Agency, who emphasise community responsibility for financing maintenance, and the opinion of communities themselves who re-state the difficulties they face in mobilising funds. Although district assembly staff recognise the limitations of community finance the evidence suggests that DA finances are similarly limited.

### 6.4.8 District Assembly capabilities

This section assesses the extent to which Akatsi and East Gonja District Assemblies, and specifically their respective District Water and Sanitation Teams

(DWSTs), are able to fulfil their mandated responsibilities as laid out in the CWSA guidelines. The findings in this section are based on interviews with District Assembly staff as well as CWSA staff at national and regional levels (see Appendix C.3 for the schedule of interviews undertaken). The interview responses were compared with available policy, budgeting, and planning documentation.

To provide context to this analysis it is important to note the high levels of support that Akatsi and East Gonja district assemblies have received in recent years first from DANIDA funded projects and then as part of the Triple-S project[40]. This may mean that the practices in these case study areas may not be representative of other District Assemblies across rural Ghana.

#### 6.4.8.1 Funding of District Water and Sanitation Team (DWST) monitoring

According to the stated guidelines (summarised in Table 6-3) the DWST should undertake regular community monitoring to identify issues with WATSAN system management, financial management and technical issues with the systems. On the back of this monitoring action plans should be developed - detailing priority issues in each community to be followed up by the DWST (Akatsi District engineer, 2013).

All of the eight district assembly staff interviewed in the two districts stated that currently these activities were taking place but only because of the ongoing financial support of donors. These statements were supported by the available documentation. In East Gonja there was no evidence (in the form of action plans, or a breakdown of proposed activities) of any systematic community monitoring prior to the funding of Triple-S activities. In Akatsi, the previous DANIDA project had ensured monitoring systems were in place as part of a “monitoring operation and maintenance” programme, but these activities had lapsed prior to the involvement of Triple-S.

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[40] Further details of this support is provided in Appendix: F.3

The experience in Akatsi and East Gonja is that donor funded monitoring activities are packaged together with daily subsistence allowances (DSA) to compensate staff for time away from the DWST offices. There was a consensus amongst the district staff that without these incentives there is little motivation for staff to travel the long distances between rural communities, as one member of DWST in Akatsi stated that “without it (the DSA) you do not feel obliged to do anything”.

Aside from donor support, DWST activities are financed through prepared operational budgets funded by the District Assembly. The experience of the two districts is that very little if any funds are made available for non-infrastructure projects.

The district engineer and head of the DWST in Akatsi district outlined the precariousness of district assembly funding. In three successive years (2009, 2010 and 2011), the he had submitted operational plans and budgets for DWST monitoring activities and administrative office costs – these had been approved and incorporated into the District Assemblies Medium Term Development Plan (MTDP) - which is the basis of District Assembly Common Fund (DACF) disbursements. However the approved allocations to the DWST did not materialise because every year DACF allocations were lower than expected and the operational budget for WASH activities were not prioritised amongst all the other activities of the District Assembly. The engineer stated that the repeated failure to secure funds means that the DWST no longer bothers to prepare operational plans or budgets.

#### 6.4.8.2 The use of the District Monitoring and Evaluation System (DiMES)

According to regional CWSA staff the DiMES database – the existing nationwide water point monitoring software as described in section 6.3 - is not being used or updated in a systematic manner meaning that even basic information on asset construction, location, and functionality are outdated.

Specifically DiMES was thought to be: over-elaborate with many redundant data fields; not fully functional as it was unable to generate functionality and coverage reports and difference scales; and slow cumbersome to use. These weaknesses were borne out when the DiMES system was tested[41].In Akatsi and East Gonja districts DiMES was only ever updated to log new system construction – with no tracking of system performance or functionality. Consequently, DiMES is only capturing the notional "coverage" provided by constructed systems ignoring any service slippage has occurred and this will impact the effective targeting of investment throughout district, regional and national planning processes.

#### 6.4.8.3 Providing financial and institutional support to communities

The data in the asset inventory demonstrated that the district assemblies rarely finance system rehabilitation. Members of the Akatsi DWST could not recall any occasions when the district had financed either the ongoing maintenance or rehabilitation of a rural water point system. In East Gonja informants stated that during the recent election campaign, and in response to community protests, the district council did fund the rehabilitation of a small number of systems after Triple-S system monitoring had concluded.

This component of the Triple-S project was focussed on infrastructure monitoring but not explicitly on the additional DWST responsibilities such as committee re-retraining, providing technical guidance, or undertaking financial auditing of WATSAN accounts. Members of the DWST in both districts could not recall an occasion when the re-training of a committee took place. Technical support is provided occasionally, but was usually prompted by community members visiting the DWST office and therefore was most often associated with communities located close to the district capital.

The current capability of District Assemblies to fulfil their mandated roles seems to be dependent on the ongoing donor support of operational activities. This

[41] As part of the research inputted data in the DiMES framework was reviewed and this reflected these substantiated these problems. In particular it was telling how few of the fields were completed for each system. Under the data tab "facility data management", there are 158 unique data fields relating to the characteristics, costs, and hydro-geological information of each supply asset. Of these, in nearly all cases only 7 fields are filled relating only to when and where the system was constructed.

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echoes the final evaluation of DANIDA's support to rural District Assemblies. This evaluation concluded that at the point of withdrawal of DANIDA support:

*"There is very little evidence of DA capacity to sustain the DWSTs by providing more financial and logistic support. In addition, in many communities the WSMTs, which are key to sustainability, do not have sufficiently robust accountability systems and motivation to operate sustainably" (Particip GmbH 2008)*.

The ability of the District Assembly to finance the activities of the DWST is dependent on the extent to which financial and operation planning at district level is incorporated within the broader budgeting processes at national level and eventually reflected in the dispersements from national government and line ministries to fund district assembly activities. These budgeting and planning processes are outlined and critically analysed in Appendix G. Out of this analysis two key limitations of current processes have been identified:

1) Focus on capital investments:

A review of the DWSTs and MTDPs in Akatsi and East Gonja show that the only items included in to plan relate to new capital investments. No plans were included which addressed the core operational activities of the DWSTs, such as funding for monitoring and community support, in addition the District had not planned for any funding for the maintenance or rehabilitation of failed systems.

2) Reliance on donor funding:

There is a disconnect between the items detailed in the District Water and Sanitation Plans (DWSP) and the budgeted funds. In the case of Akatsi and East Gonja none of the activities detailed in the most recent DWSP were incorporated into the final composite budget against which finance can be raised. The district and CWSA staff interviewed stated that the costs of items in the plan are expected to be met solely by donors.

#### 6.4.8.4 Current expenditure on supporting community service delivery

Requests were made within the district assembly, and the CWSA, for recorded levels of expenditure on Direct Support. No data was available from either source precluding a full expenditure analysis. A financial review of internal documentation within Triple-S, however, showed that the average expenditure to collect, validate, and share asset inventory data for a single district in a single year was $6,525 – excluding the salaried costs of district staff (a full break down of the costs of Triple-S asset monitoring are shown in Appendix: F.1). This equates to an expenditure of approximately $0.05 per person.

## 6.5 Summary and implications

### 6.5.1 The sufficiency of current expenditure

This examination of the functionality of assets in Akatsi and East Gonja raises important issues for service authorities and service providers alike. The national water policy of Ghana recognises the "fundamental right of all people without discrimination to safe and adequate water to meet basic human needs" (GoG, 2007). The data collected shows that significant investment in rural water points over the past 10 years has pushed up coverage rates and delivered first time services to many new areas.

However these advancements in coverage are tempered by high rates of non-functional water points. The data shows that 5 years after construction nearly half (47%) of these water points are "non-functional". This has a significant impact on overall access to formal sources with the 2013 data showing that over 30,000 people in the case study districts (22%) suffer from service "slippage" where they no longer have access to a functioning formal source.

In terms of system management the practices of key community, district, and national stakeholders are found not to be in compliance with their prescribed roles and responsibility as defined in Table 6-3. At community level around a third of water points (31%) are not managed by a WATSAN Committee and at a quarter (28%) of water points no tariff is levied. This does not comply with CWSA guidelines and appears to be linked to higher rates of non-functionality/postponement of repair.

The data clearly shows that the main reason (68% of cases) that systems are not repaired is because communities are unable to mobilise adequate financial resources. The present median annual maintenance expenditure by the community of $14.4 per water-point, represents just $0.05 per person per year assuming 300 users per system. Current maintenance expenditure is demonstrably insufficient to ensure the functional sustainability of all the water point systems in the case study districts and is indicative of an unwillingness of communities to pay for formal water sources.

Analysis of the incidence of water point rehabilitation shows this happens very infrequently and in an ad hoc manner. Indeed only a single instance of water point rehabilitation was recorded in the 14 months between the two asset inventories. Interviews with key informants suggest that ambiguity within the guidelines over who should pay for rehabilitation means that both district and communities are able to abdicate themselves of this responsibility. This reflects insufficient levels or expenditure resulting in a very slow response to serious asset failure.

At district level, serious financial resource constraints linked to problems with financial allocations from central government means that District Assemblies cannot independently fulfil their mandated responsibilities to support, monitor and financially backstop rural water service delivery.

### 6.5.2 Assessing the challenges of financing maintenance, repair, and direct support

Once breakdowns occur many communities are not able or willing to meet the costs of repair. Examination of existing maintenance expenditure shows that in some cases repairs are being carried out at relatively low cost (at around $25 per repair). From existing corrective maintenance data it is a realistic assumption that amongst some of the non-functional systems identified only minor repairs are required to restore functionality and the fact that this does happen demonstrates a low effective demand (willingness to pay) amongst users.

The contention is further supported community records and interviews show that effective demand for formal water services is much higher in the dry season compared to the wet season, due to the availability of alternative informal water sources (see Appendix F.2 for details). This trend is consistent with similar findings from rural areas in Mali (Gleitsmann et al, 2007) and Kenya (Whittington et al, 1989) and shows that community members are able to pay for services when free alternatives are not available. Moreover simple financial analysis showed that even assuming a low price of water, and with low consumption, potential tariff revenues are ten times existing maintenance expenditure and should be able to fund many of the maintenance activities that are currently stated to be unaffordable.

The financial gap between potential income and very low actual expenditure (due to a stated lack of funds) suggests that even when a tariff is being levied potential revenue may be significantly below expected levels. The disparity between potential and actual revenue and how tariffs are collected and used at community level needs to be investigated further.

The CWSA guidelines (CWSA, 2012), as well as wider sector literature (WaterAid, 2011; RWSN, 2010; Montgomery et al., 2009; Carter et al., 1999), recognise that community based organisations required systematic and ongoing institutional support if rural water services are to be sustained. This support involves the sensitisation of community members to the necessity to use and pay for formal water services, but also support and technical advice to the community organisations in how to best manage and maintain these supplies (CWSA, 2012).

Periodic sensitisation activities are not happening systematically, but even so it remains unclear at what level of support, if any, would communities be willing to contribute more to the ongoing and effective operation and maintenance of systems. Moriarty et al. (2013), contend that the relationship between direct support expenditure and service delivery outcomes is unlikely to be linear. Instead, direct support is thought to work according to a threshold affect whereby below a certain level of expenditure little service improvements are likely to be recorded.

It is also likely that there are other factors not associated with the level of support. As documented in the literature the effectiveness of community management effective community participation can be hampered by social and economic factors, such as: religious fractionalisation (Miguel and Guerety, 2005), a lack of

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shared values (Ostrom, 1990), a lack of genuine engagement in the need to pay for services (Jones, 2013).

In addition to minor handpump breakdowns there will undoubtedly be a number of breakdowns that are more significant and will require levels of expenditure that are beyond the ability of communities to finance in the short term – especially if the community has not been collecting tariff revenues. This situation is compounded by the fact that planning and budgeting processes at district level are not accounting for these costs and are instead prioritising the construction of new infrastructure – which is ultimately financed by donors.

For these reasons the mobilisation of sufficient funds at the point of a major failure – a “fix on failure” approach – is not happening and is a major cause of prolonged periods of infrastructure breakdown.

The reliance of the District Assemblies on donor financing comes with its own set of sustainability challenges. Historically without partners to fund the data collection and with WASH monitoring not being prioritized through national level allocations, the district water and sanitation teams have been unable to ensure data is collected, analysed and utilised. This is recognised across all WASH governance levels and has a direct effect on how planning is undertaken; Mr Kubabom, the director of Planning and Investment at CWSA, recognizes that:

> *This is where we fall short; we do not have enough support from government in terms of our administrations and our operations budget to be able to go out and monitor what the situation is in communities.*

Outside the scope of the two focus case study districts where Triple-S has supported district activities there is a fundamental mismatch between the policy expectations on the District Water and Sanitation teams and their actual capacities to perform all the functions assigned to them.

Across low-income and resource poor countries, contemporary studies suggest that very active donor and project environments can have a corrosive effective on the willingness of institutional staff to fulfil their day to day responsibilities. Specifically the added incentives that often accompany donor projects can encourage opportunistic behaviour as staff seek to tap into so called "development rent" (Olivier de Sardan, 2012) or partake in a 'hunt for per diems' (Soreide et al., 2012) from development organisations rather than pursuing salaried duties.

Within Akatsi and East Gonja, Triple-S project activities have supported district monitoring activities but not the full scope of duties required of the DWST, as laid out in CWSA guidelines (CWSA, 2012). Interviews with staff members clearly show a perceived dependency on donor funding. This results in DWST members aligning their work around the project activities ahead of other activities as these are the areas where basic funds for logistics (such as transport and travel) and also additional funds for staff members (such as per diems) are available.

**Table 6-13: Summary table on the status and implications of the financing of service delivery costs in rural Ghana**

| Life-cycle cost component | Activities | Responsible organization | Actual practices | Implications/recommendations |
|---|---|---|---|---|
| Capital expenditure hardware | Construction of new water points | National and international donors and the government of Ghana | - Evidence of high levels on investment in recent years – 61% of water points constructed within the last 10 years and coverage rates (measured simply as the number of systems constructed) are increasing.<br>- As stated the vast majority of new current expenditure is financed by transfers from international donors (Transfers) with very occasional financing from local NGO's and government agencies.<br>- Critical analysis of financial planning process from district level upwards shows the rural sector is orientated around generating finance for new capital investments – typically from donor organisations. These decisions are based on information captured in the DiMES database – however this study has shown the across rural districts this database is not updated and not functional (see Appendix G). | - The mobilisation of donor funds for new capital projects has been very effective and seems a viable means to extend coverage to new areas.<br>- The effective prioritization of new investment to areas of greatest need will likely be undermined by ineffective planning and monitoring due to inadequacies in both the DiMES systems and the limited resources of the DWSTs (applicable to all rural districts) that are rarely to incorporate functionality and hydro-geological indicators into planning. |
| Operational and minor maintenance expenditure | Greasing, inspection, periodic and minor corrective maintenance | Communities | - Nearly half of all water points are listed as non-functional within 5 years.<br>- 80% of communities undertaking some form of water point maintenance (mean expenditure $14.4 per water point), but linkages between the type of maintenance that is undertaken and levels of functionality suggest that many repairable failures could be fixed with relatively little increases in periodic and corrective maintenance.<br>- The most common reason why maintenance was not undertaken was due to a lack of funds suggesting either an insufficient willingness or ability to pay for maintenance.<br>- Communities which levied a tariff achieved higher functionality rates. | - Insufficient maintenance expenditure is linked to a low effective demand for formal water services from point source/handpump systems.<br>- Wider literature suggests that to improve willingness to pay is linked to greater levels of community engagement, sensitization and participations, itself linked to periodic and systematic institutional support and training (WaterAid, 2011; RWSN, 2010; Montgomery et al., 2009; Carter et al., 1999).<br>- Indicative analysis shows that required expenditure is between six or eight times existing expenditure (see section 6.6.1) and should be affordable if tariffs are effectively collected (G.2). However this cannot be assumed particularly because of the seasonality |




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| | | | | |
|---|---|---|---|---|
| | | | | in demand which means that community demand for these sources can only support a “slow fix on failure”. |
| Capital maintenance expenditure (hardware) | Rehabilitation of the hand-pump or borehole after major breakdown | Communities & District Assemblies | - Rehabilitations are very infrequent – only one (1) documented in the 12 months between the 2011 and 2013 surveys.<br>- District assemblies do not budget for this expenditure and rehabilitations are not prioritized. Additionally rehabilitations are systematically included in the planning process meaning donor funds are only mobilised in an ad hoc manner.<br>- Communities do not feel financially responsible for the rehabilitation of water points and are unwilling to finance these expenditures. | - CapManEx should be financed through “tariffs” and “taxes” but is proving unaffordable to all these stakeholders – seriously threatening the long term sustainability of systems.<br>- Systematic monitoring of borehole functionality and the types of failure - captured in an improved and functional DiMES system[42] - would allow major borehole failure requiring rehabilitation to be accurately recorded and budgeted for by donors or government agencies. |
| Expenditure on direct support | District Assembly: Technical and managerial performance monitoring, financial auditing, and technical support and backstopping. | CWSA & District Assemblies: | - Direct support activities are not being financed or prioritized by local or national government. This means that the activities of the DWSTs are dependent on and shaped by donor priorities. This means that there is little evidence of institutional support to ensure communities remain motivated and trained.<br>- Triple-S activities in Akatsi and East Gonja effectively support ongoing monitoring but not the direct support of the communities.<br>- According to stakeholder feedback the indicative estimated ideal direct support expenditure seem to be well beyond the current willingness of capacity of local or national government (section:6.6.4). | - The effective management of community systems has been shown to be linked water point functionality. Safeguarding better management likely requires much better and more systematic support to communities to seek to improve the effective demand for services. It is unlikely that given current practices and resources that these funds will be financed by national governments. |

[42] There are plans for Triple-S to support CWSA in revising the DiMES framework, streamlining the indicators it is designed to capture and linking it directly with the mobile monitoring of water services. A revision of DiMES would aim to be able to incorporate appropriate asset management indicators for small communities and small towns.

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The following section uses asset inventory cost and functionality data to provide indicative estimations of what the ideal levels of expenditure would be to safeguard improved asset management of systems.

## 6.6 The financial costs of improving asset management

### 6.6.1 Operational and minor maintenance expenditure

A focus group with area mechanics provided insight into the “ideal” annual operation and minor maintenance expenditure for each water points.

The total cost of undertaking an annual inspection of the system is estimated at $62. This includes labour charge of the area mechanic (varying between $15 and $25 for each call out), transport costs and the replacement of items such as cup leathers that tend to wear out quickly. The area mechanics state that annual removal of the handpump and inspection of the cylinder and rising main allows for problems of leakage and mis-alignment of the below ground works to be swiftly addressed. This ensures the continued performance of the system, and provides resilience against future major breakdowns.

On occasion the handpump will experience other minor breakdowns that will also require the attention of the area mechanic. The asset inventory suggests the median costs of repairing these will be $25 and these are assumed to be required every 2 years. These maintenance costs should be borne by communities on an annual basis and correspond to an estimated $80 per system per year, or $0.27 per person per year (Table 6-14).

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**Table 6-14: Required idealised maintenance expenditure for rural water points**

| **Activity** | **Annual Cost per system** | **Estimated cost per person** |
|---|---|---|
| Greasing and general upkeep | $5 | $0.02 |
| Annual inspection and replacement of fast-wearing parts | $62 | $0.21 |
| Occasional corrective maintenance | $13 | $0.04 |
| Annual maintenance expenditure | $80 | $0.27 |

* Assuming 300 users of the water point[43]

### 6.6.2 Capital maintenance expenditure

The analysis of water point data from 2011 and 2013 demonstrates that just over half (52%) of the water points in the two sample districts required rehabilitation within 5 years of construction. An assessment of rehabilitation in Akatsi district found that the mean expenditure on capital maintenance of a handpump was $194. If handpumps are assumed a median time to major breakdown of 5 years, this means that $39 should be budgeted on an annual basis for CapManEx. The potential capital maintenance cost of replacing, or flushing, a borehole have not been included as these assets have an expected lifespan of 30 years.

### 6.6.3 Indicative annual maintenance expenditure

Working on the assumption - borne out in the collected asset inventory data – that regular periodic/preventative maintenance can make handpump systems more resilient to major breakdown; Table 6-15 explores the potential impact on different periodic maintenance strategies on the length of time until the handpump needs to be a repaired (it's lifespan) and correspondingly the total annual budgetary requirement for maintenance.

This indicative analysis shows that the most low-cost approach to maintenance is "scenario 3: only greasing + corrective maintenance" with an estimated

[43] Water quality testing has been excluded from this triangulation - according to the CWSA guidelines the water quality of each point source should be tested twice a year – this represents a significant potential operational expense. The cost of water quality testing was estimated from an unpublished bill of quantities from the CWSA office in the Northern and is given at $78.

budgetary requirement of $67 per year, despite the fact that major breakdowns may be more common. The most high cost approach is “scenario 1: annual periodic maintenance” with an estimated budgetary requirement of $104. Despite appearing to lower costs scenario 3 carries a greater degree of potential risks of declining functionality and a higher incidence of regular and unpredictable breakdowns. As a consequence scenario 1 and 2 are preferred approaches yielding a guideline annual budgeting requirement of between $72 and $104 per water point.

**Table 6-15: Indicative maintenance scenarios and costs for rural water point systems**

| Maintenance approach | Annual expenditure on maintenance* | Assumed interval until major repair required/ yrs. | Annual budgetary requirement for handpump CapManEx | Total annual expenditure/ budgetary requirement for maintenance | Potential risks |
|---|---|---|---|---|---|
| Scenario 1: Annual maintenance | $80 | 8 | $24 | $104 | Mobilising community finances when no apparent failure with the system. |
| Scenario 2: Occasional periodic maintenance (every two years) | $40 | 6 | $32 | $72 | Mobilising community finances when no apparent failure with the system. |
| Scenario 3: Only greasing + corrective maintenance | $18 | 4 | $49 | $67 | Potential declining functionality due to increased risk of leakages.<br>More regular and unpredictable breakdowns leading to extended periods of downtime. |

*This does not include water quality testing - as it is not considered to affect the technical functioning of the handpump - or the costs of borehole re-siting/flushing, or redigging a hand-dug well, which are not identified in a major cause of system failure.

## 6.6.4 Required expenditure on direct support

The amount service providers and service authorities should be spending on monitoring and supporting water delivery is a contested point and is not entirely resolved in this study.

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The Triple-S project convened an expert group to estimate the necessary levels of expenditure required to for DWSTs to adequately support community activities. The expert group broke down district assembly activities into 3 areas. Field activities - including monitoring to each community, participation in community meetings, and auditing of community accounts; Planning and office activities - including the development of the district water and sanitation plan and updating DiMES; and administration and logistics – including maintenance of office equipment and transport. A unit cost was given for each of these activities producing a required direct support cost for a typical district of $28,703 (Triple – S, unpublished). These values do not include the core staffing costs of the DWST or any financial costs of system maintenance or rehabilitation.

Applying this value to Akatsi and East Gonja district populations gives an ExpDS of $0.23 per person, per year in Akatsi and $0.24 per person per year in East Gonja. These estimated levels of expenditure constitute between 5.6% and 6.1% of the entire District Assembly Common Fund (DACF) allocation to each district assembly (according to the allocations over the last 3 years - Table 6-16). Assembly leaders in Akatsi and East Gonja considered this ideal expenditure as unrealistically high given the competing demands on district funds. They reasoned that this level of expenditure could only be met by donor support.

**Table 6-16: Expert group estimate of “ideal” direct support expenditure compared to DACF dispersals**

| District | Population | “Ideal” ExpDS | “Ideal” ExpDS per person | Annual District assembly common fund disbursement | | | | ExpDS as a % of DACF |
|---|---|---|---|---|---|---|---|---|
| | | | | 2010 | 2011 | 2012 | Average | |
| Akatsi | 127,304 | $28,703 | $0.23 | $468,769 | $644,570 | $433,125 | $468,769 | 6.1% |
| East Gonja | 117,606 | $28,703 | $0.24 | $353,056 | $665,759 | $548,478** | $509,408 | 5.6% |

*ExpDS – Expenditure on direct support
**No 4th quarter data was available for East Gonja in 2012. This total has been generating by estimating the 4th quarter dispersal as the average of the dispersals for quarters 1, 2 and 3.

Furthermore, this level of expenditure greatly exceeds what the Triple – S project spent undertaking infrastructure data collection, validation and dissemination (including transport, travel and per diems). The direct cost of these data collection totalled US $6,525 (US $0.05 per person) representing considerably less than the expert group estimate at 1.3% and 1.4% of the DACF allocation – but still considered unaffordable by the district.

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# 7 Conclusion

## 7.1 Introduction

This thesis set out to explore how much it costs to provide people with “basic” water and sanitation services in rural and small town areas of lower-income countries. This apparently simple question has not been satisfactorily addressed within academic or sector literature, and inconsistencies with how cost data has been collected, categorised, and analysed means there is only partial knowledge of what it costs to construct water and sanitation systems, and virtually nothing is known about the necessary levels of expenditure required to sustain these systems.

To address these gaps, this study has analysed cost and service level data relating to a diverse range of water and sanitation systems from five lower-income countries. This data was collected and analysed using a common methodological approach in collaboration with researchers from the “WASHCost” and “Triple-S” projects hosted by the IRC: International Water and Sanitation Centre in The Hague.

Specifically this study sought to address two primary research objectives:

- *To determine what has historically been spent on providing different levels of water and sanitation service*
- *To provide guideline data on the necessary levels of capital and recurrent expenditure require improve the sustainability of water and sanitation services*

Each of the primary objectives is accompanied by a series of sub-objectives designed to inform a better understanding of how costs and service levels vary between different technologies and country contexts, and to explore the inter-relationship between unit cost expenditure and service outcomes.

To address research objective one a broad range of financial cost data was collected at a variety of different governance levels within each country. The provenance of each data source was recorded so cost values could then be attributed to the relevant water or sanitation system. The service delivered by these technologies was recorded at household level through over 10,000 household surveys undertaken across the five country studies. The analysis for research objective one – how much has been spent on water and sanitation - also informed a general assessment of what should be spent to sustain these services as a component of research objective two.

The final component of this research sought a specific analysis of the expenditure required to sustain rural water services through the analysis of comprehensive asset inventory data for two rural districts of Ghana. This quantitative data was complemented by qualitative information collected from key informants at community, district, regional, and national levels to help inform wider understanding of planning, budgeting and financing processes. In combination these data sources enabled a systematic comparison of community expenditures with water point functionality, whilst also examining wider relationships between institutional support, water point management, maintenance expenditure, and water point functionality.

## 7.2 Limitations of the study

The main weaknesses of the data have their origins in the country-led data collection approach, which meant that type and sample size for the systems collected varied greatly, limiting the options for cross country statistical analysis; also that the implementation of the common data collection methodology varied, limiting the cross-country comparability of service level indicators. Other weakness are inherent to the collection of cost data in lower-income countries where the fragmentation of data across different sources and the generally poor record keeping made it difficult to ascertain if complete or partial cost data has been collected.

Furthermore, despite exhaustive efforts of data validation in collaboration with country research teams, the scale of WASHCost data collection, and it's scheduling before the start of the PhD research, meant that some uncertainties in the original data sample could not be resolved. These factors also meant that any local contextual factors influencing costs or service delivery could not be systematically analysed. However, additional data collection by the researcher in Ghana and Sierra Leone enabled a more nuanced understanding of the specific operational context in each of the communities sampled, which could then be incorporated into the interpretation of findings.

The remainder of this Chapter is structured as follows. It first sets out the synthesis of empirical findings from all the analysis chapters in relation to the each of thesis sub-objectives. This is done in a systematic manner addressing each sub-objective in turn. These findings are then drawn together as part of a series of short discussions, linking the thesis research with implications for theory and for policy. Finally, avenues of future research are proposed followed by a final summation of the relevance of the thesis for policy-makers.

## 7.3 Empirical findings

The analysis of empirical findings was presented in Chapter 4: Rural and small town sanitation costs; Chapter 5: Rural and small town water supply costs; and Chapter 6: Detailed investigation of the costs of water services in rural Ghana. The overview of historic costs for each technology and country (sub-objectives 1.1 and 1.2) are provided in each of the respective analysis chapters and are not repeated here. This synthesis of findings for the remaining sub-objectives are given below.

***Sub objective 1.3:*** *To provide insight in how effective sector expenditure has been in delivering the sector goal of a "basic" water and sanitation services, as opposed to simply coverage.*

a) **Achieving first time access to infrastructure does not guarantee the delivery of a "basic" level of improved services.** This was found to be most problematic for water supplies where in nearly all cases less than half of those accessing and using a formal water supply system were receiving the target of a "basic" level of service. Similarly regarding sanitation, only 55% of households with an "improved" latrine received a "basic" level of sanitation services in rural areas, although this figure rises considerably to 83% for improved latrines in small towns.

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***Sub objective 1.4:*** *Assess the effect of expenditure, technology and location on water and sanitation service levels.*

For this sub-objective the empirical findings for water and sanitation are discussed separately.

**<u>Sanitation</u>**

a) **Higher levels of capital expenditure are a pre-requisite for basic services.** The most expensive latrines to construct, and those delivering the highest level of service, are the single and double pit pour flush latrines sampled in Andhra Pradesh state, India. Amongst the African countries, the quality, type, and cost of the latrines were much more diverse. Yet even so, in all comparisons the latrines which delivered more favourable services were more expensive to construct (although these differences were not found to be significant in all cases), and in most cases this costs and service level difference will be influenced by the extra cost of purchasing an impermeable concrete slab.

b) **"No cost" latrines provide limited service.** In rural areas of Mozambique and Sierra Leone, most latrines are constructed using local materials at minimal or no financial cost to the households. As a corollary to the previous finding, "no cost" latrines rarely provide adequate faecal separation by WASHCost or JMP definitions. Furthermore in the case of Sierra Leone the vast majority of these latrines were found to be dirty and fly infested, representing a health risk to users.

c) **Achieving sustained latrine use, cleanliness, and reliability are problems for all – but are greater in rural areas.** Sustaining acceptable sanitation and hygiene practices is found to be a significant challenge for all latrines – although it was found to be most acute in rural areas, and for lower cost technologies[44]. Note that this is not so much an issue of capital expenditure, though is likely influenced by the perceived quality of infrastructure.

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[44] The exception to this finding are the data points from Mozambique where few issues with latrine use and cleanliness were recorded. However these differences are thought to be most likely explained by the different methods that were used to collect these indicators.

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## Water

a) **Unreliable services are being delivered at high costs.** Most of the water supply systems that were sampled suffered from regular and prolonged breakdowns, meaning that for long periods no service benefits were being delivered despite significant capital investment. The poor reliability record demonstrates that the current levels of expenditure on system maintenance are insufficient to maintain a "basic" water service to rural and small town areas.

b) **Point source vs piped systems, marginal service improvements at high cost.** Results from the African countries indicate that users of piped schemes do achieve higher levels of service (between an 18% and 44% increase in those achieving a "basic" service) than users of boreholes with handpumps, but this is coming at a five and eight fold increase in per person capital expenditure, and well over a thirty fold increase in maintenance expenditure per person, per year.

c) **High price for service resilience in Andhra Pradesh, India.** In contrast to the African context, service users in most rural and small town communities in Andhra Pradesh have access to multiple water systems within close proximity to their households. The majority of these systems have been found to be unreliable and suffer regular and prolonged breakdowns. Despite this, the combination of sub-optimally performing systems are able to provide users with more 'improved water service' than any other country sampled. This reliance on multiple overlapping of unreliable systems suggests that there is significant scope for achieving efficiencies by improving the maintenance of existing infrastructure, rather than the reliance on new system construction.

d) **The potential of self-supply.** A very limited sample of self-supply systems in Sierra Leone demonstrated that the per person capital costs of these systems was lower than the equivalent cost of most piped systems in Africa and delivered users with a better overall service. However, the capital costs of community systems are almost exclusively borne by governments and donor agencies, whereas the capital costs of self-supply systems are borne by households themselves. Therefore given current financing arrangements these systems would not be affordable to the very poor.

***Sub objective 2.1***

*To undertake a general assessment of the necessary expenditure required to sustain water and sanitation systems based on WASHCost data on costs and service levels from five countries.*

<u>**Sanitation**</u>

a) **The necessary (“normative”) capital cost of a latrine varies between countries.** In Andhra Pradesh, the required expenditure to construct a robust latrine is approximated as the median cost from the sample of pour flush latrines (median cost $181 per latrine; inter-quartile range $125-$255). Findings from Mozambique and Sierra Leone demonstrate that a formal latrine with a slab can be constructed for $ 40, although if expenditures fall below this level, the latrines are unlikely to be constructed from robust materials. In contrast, the indicative cost of similar latrines in Burkina Faso and Ghana are somewhat higher at approximately $100 per latrine.

b) **Uncertain linkages between operational expenditure and latrine cleanliness.** At the aggregate level the data does not show any relationship between expenditure on soap and latrine cleanliness. However, the more detailed country study in Sierra Leone found that the small number of households with a clean latrine were spending around five times as much (mean $2.4 per person, per year) on soap and detergents than those households with extremely dirty and fly infested latrines spent (mean $0.5 per person, per year).

c) **Pit emptying is rare, and the costs are largely unknown.** Insufficient primary data was collected to ascertain the costs of pit emptying across the different countries and technologies. Secondary data from urban areas suggest that the costs of mechanical pit emptying may be considerably greater than existing operational expenditures and are therefore likely to be considered unaffordable by users. Further uncertainty remains regarding the length of time it takes for a pit to become full, as well as the cost of different pit emptying strategies in rural and small town areas. These remain key gaps in sector knowledge.

**<u>Water</u>**

a) **Insufficient operational and capital maintenance expenditure means service delivery is stagnating.** Across all country contexts the failure to maintain or rehabilitate water supply systems results in extended periods of asset breakdown. Comparison between the current amounts being spent and the estimated capital maintenance requirements of these systems suggests a very significant financial shortfall. Amongst the African countries these shortfalls are most profound, with normative maintenance requirements estimated at between five and six times existing expenditure for piped systems and over forty times existing expenditure on community point sources. In Andhra Pradesh required maintenance expenditure is estimated at between 1.3 and 3.0 times current levels.

**<u>Both water and sanitation</u>**

a) **Slippage in service delivery suggests an absence of systematic direct support.** The slippage in latrines' usage and maintenance, as well as the evident difficulties in mobilising community funds for water system maintenance, are suggestive of insufficient expenditure on providing ongoing support and training to households and community organisations after the initial start-up investment.

***Sub objective 2.2***

*To undertake a specific assessment of the necessary expenditure required to sustain water services in rural Ghana based on a comprehensive inventory of asset functionality, management, and financing arrangements in two districts.*

a) **Borehole and handpump systems have an estimated maintenance requirement of between $71 and $104 per system per year.** This includes the annual periodic maintenance of the system by the district area mechanic, as well as budgetary provision for occasional major repair of the handpump. Assuming 300 users per water point this equates to an annual maintenance expenditure of $0.25 - $0.35 per person, per year.

***Sub-objective 2.3***

*To assess the impact of current management and financing practices at community and district levels on the functionality of rural water points in Ghana*

a) **Effective demand for formal water services is low and seasonal.** The normative (required) maintenance expenditure on a community point source is shown to be between six or eight times existing expenditure, however this represents between just $0.25 and $0.35 per person per year. This level of expenditure could be covered by even modest tariff revenues, however users are not prioritising expenditure on formal water sources especially when alternative sources are available. This results in a very slow response to failure, but represents a level of service that communities are willing to pay for.

b) **Improved community management leads to improved functionality.** Communities which have an active water and sanitation committee and levee a tariff for water services are seemingly more likely to maintain and repair community water points than other communities. This indicates that increased systematic support to communities may be able to improve existing effective demand for formal water services. However the nature of the relationship between "direct support" and community demand for services remains unknown.

c) **No-one takes responsibility for capital maintenance.** The very infrequent incidence of water point rehabilitation demonstrates that no agency financially plans for the costs of capital maintenance.

d) **District water and sanitation teams are unable to fulfil mandated roles without ongoing donor assistance.** Internal planning and budgeting processes do not provide DWSTs with funds for office administration, asset monitoring, or community support and backstopping. When these activities occur they are almost exclusively financed through donor projects.

## 7.4 Theoretical implications

The theoretical proposition of this thesis was that an improved understanding of relationships between the unit cost "inputs" and service level "outputs" of water and sanitation provision could help optimise the cost efficiency of sector investments; and in so doing maximise the overall "pareto efficiency" of sector investments.

However in the case of water supply, the empirical findings emerging for the historical analysis are showing that very low levels of expenditure are being incurred by national level service providers and low levels of service are being delivered. The apparent insufficiency of current maintenance expenditure leaves very little scope to explore how to optimise the level of expenditure for individual technologies ("technical efficiency") – other than the simple conclusion that additional system maintenance is required. In the evaluation of "productive efficiency" – that is the assessment of the most cost efficient approach amongst the different technologies – the water supply results demonstrate that no one technology type, or indeed no single country context, are achieving more cost effective service delivery.

The clearest differences in the levels of service achieved are between point-source and piped systems in the African countries; however these marginal improvements in service are achieved at significant higher levels of capital and recurrent expenditure. Similarly, the analysis of sanitation costs and service levels showed that improved latrines provided a considerably higher service to users than unimproved latrines, however these were achieved at a much greater cost. In this scenario the determination of the most "efficient" investment choice requires systematic consideration of economic costs and benefits at each levels of water or sanitation service. Such analysis is beyond the remit of this thesis, but nevertheless represents a very interesting avenue of further research, which may utilise the uncommonly detailed (for the sector) financial cost data presented in the thesis alongside a detailed economic assessment of the health and social implications of different levels of service delivery.

## 7.5 Policy implications

The policy implications for water and sanitation service delivery are discussed in turn.

### 7.5.1 Water

This thesis contends that low levels of recurrent expenditure on water supply systems are symptomatic of the insufficient "effective demand" that residents in developing countries have for the type of service that meets minimum global standards.

For example the large seasonal variations in water revenues in Ghana demonstrates that the reason why formal water points are not repaired in a timely manner, and therefore the reason why some 48% of systems are found to be "non-functional" after 5 years, is not necessarily because of an inability to finance repairs, but rather a lack of "effective demand" for these services. Put another way the current mean expenditure on borehole and handpump maintenance in rural Ghana is $14.4 per system per year (approximated $0.05 per person per year) and this represents the actual level of effective demand (the willingness to pay) of residents for an irregular water supply service with a "slow-response" fix on failure approach to maintenance for these point source systems.

This inability/unwillingness to make the required spending is also evidenced within government departments. Staying in Ghana, the operational activities of the District Water and Sanitation Teams were entirely dependent on donor funding, despite repeated efforts to secure promised allocations from the government.

For piped systems in Africa, the necessary expenditure required to meet the "normative" maintenance requirement is multiple times the level of existing expenditure. The failure to meets these costs are considered to be a major factor in poor reliability of these systems. However these challenges are not unique to rural and small town areas, for example the "IB-NET" database of water and wastewater utilities demonstrates between 50 to 70 of water utilities in low and middle-income countries are unable to meet their ongoing operation and maintenance costs (IBNET, 2014).

This analysis raises a number of important international policy questions for current and prospective donors in the water and sanitation sector:

Recognising the current limits of “effective demand” in rural and small town Africa, to what extent is the international community prepared to subsidise the costs of water system construction, ongoing minor and major maintenance, and mechanisms of ongoing direct support in order to ensure delivery of the “basic” water services which are a key part of the Millennium Development Goals?

Given finite financial resources, how will donors strike the balance between investing in new capital expenditure to ensure that unserved areas are provided with first time access to improved services; and potentially re-allocating some of these resources to undertake the much needed maintenance of exiting systems?

In the case of water supply in Andhra Pradesh, similar policy questions need to be addressed by state and national government, particular over whether to continue to seek capital investment in new, higher service quality, water infrastructure, or to improve the maintenance of existing systems.

### 7.5.2 Sanitation

Approaches to sanitation promotion, such as Community Led Total Sanitation, specifically aim to work with poor rural communities to trigger the construction low cost latrines, commonly using local materials, and are not constructed to define technical specifications (Chambers, 2009). However this thesis indicates that in rural areas of Africa, households are unlikely to be able to construct a latrine which conforms to the JMP “improved” standard, or WASHCost “basic” standard without a financial investment of at least $40 per household, but potentially this could be considerably higher.

In the poorest communities, the capital cost of an “improved” latrine is likely to be unaffordable to households and therefore these latrines are beyond the limits of what demand promotion activities can achieve reasonably achieve. For the international donor community the implications are clear. To achieve first time coverage of improved latrines in rural areas of Africa will necessitate a systematic subsidy programme, much like the one in Andhra Pradesh, but while also recognising the ongoing requirement for community support and engagement to ensure continued use.

### 7.5.3 Conclusion

This research has answered the initial question ‘how much does it cost to deliver water and sanitation in lower-income countries?’ However the empirical findings related to water and sanitation services of unacceptable quality which are unlikely to deliver the improved health and sustainable livelihoods benefits that are the main drivers of government and donor involvement in the sector.

The research has therefore used evidence-based estimates and assumptions to determine the financial costs of delivering sustained rural water and sanitation services in lower-income countries at the desired level.

These financial costs, based on the evidence presented, are found to be far greater than the “effective demand” that both service users and national governments expressed in terms of their willingness to pay for the costs of maintenance and institutional service support.

The conclusion therefore is that if the international standards for improved water and sanitation services are to be extended to all, then the international sector, that is the higher-income countries in this context, will likely have to pay both the initial capital costs but also a significant proportion of the recurrent costs

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# APPENDICES

## Appendix A Sustainable water and sanitation services

In the global development context, sustainable development is broadly defined as a process that seeks to ensure the fulfilment of basic needs today without compromising the ability of future generations to meet theirs (Brundtland, 1987). Expanding on this definition Halliday et al. (2002) contend that for a development programme to be considered sustainable it must achieve a “triple bottom line” criteria of ensuring economic prosperity, environmental protection, and social equity.

Variations on the concept of sustainable development and sustainability have been applied across many diverse sectors, so much so that some now see sustainability as a “plastic” word (Mitchell, 1995), in that it can mean anything to anyone (Redclift, 2005). Within the water and sanitations sectors, Hodgkin (1994) recognises that interpretations of sustainability also vary in accordance to the relative value key stakeholders (donors, local/national governments, research institutions, and service users) place on different service or programme objectives.

The Global Water and Sanitation Assessment (WHO, 2000) draws a distinction between environmental sustainability, related to the impact water and sanitation systems have environment that may affect future generations or the viability of environmental resources, and functional sustainability, defined as whether sufficient skills and finances can be found to operate and maintain the system over time. The primary focus of the doctoral research is on the management and particularly the maintenance of water and sanitation asset systems; consequently in this study sustainability is examined primarily through perspective of system functionality, rather than broader consideration wider environmental resource protection.

For many practitioners working in rural and small town areas the sustainability challenge is commonly, and simply, characterized by the premature and sometimes permanent failure of water or sanitation infrastructure due to inadequate maintenance and poor management, rather than environmental constraints (Montgomery et al., 2008). In these cases a "function-orientated" definition of sustainability is seen as a more pragmatic and relevant to service providers and sector agencies (Montgomery et al., 2008; Carter et al., 1999).

One widely cited function-oriented definition of sustainability is provided by Abrams (1998) who states simply that sustainability should be judged on "whether or not something continues to work over-time". Expanding on Abrams' definition Carter and Rwamwanja (2006) argue that a sustainable system is one where the "flow of benefits" associated with system continue to be delivered over time. If this functional sustainability is reached then by definition key activities such as: effective system management, maintenance, and rehabilitation are being fulfilled (Carter and Rwamwanja, 2006). According to Carter et al. (1999), to achieve "functional sustainability", governments, service providers, and donors alike have to ensure that future investments are made in such a way as to build in an "evolving and adaptive" resilience into service delivery so future unknown challenges can be met.

The definition of sustainability as a concept is distinct from the elements and criteria that determine whether or not service delivery is sustained over time. There are many institutional (organisational), environmental, socio-economic, technical, financial, and managerial elements that are thought to contribute to the improved "functional sustainability" of rural systems (Lockwood and Smits, 2011; Parry-Jones, 2001). These will be addressed at length in subsequent sections. It is also acknowledged that that the "flow of benefits" resulting from a water or sanitation service are rarely binary (no benefits/full service benefits) and therefore when assessing sustainability different standards, or levels, of service that should be quantified.

Initially, however, this section provides a contextual overview of the evolution of the key trends in managing, financing, and maintaining rural water and sanitation systems over the past 30 years.

**Historical perspective on sustainability in the water and sanitation sector**

Throughout the 1980s most rural water and sanitation provision in lower-income countries was "supply led", that is where the sector focused on overcoming the technical and financial challenge of providing first-time services to as many people as possible (Harvey and Reed, 2006). Allied to the rapid construction of new infrastructure was an increased emphasis on the community, participation, ownership and management of rural services. At this time government-led maintenance programmes of rural systems were seen to be failing to keep systems working (Black, 1998) and so community themselves were mobilised to fill management gaps that were considered beyond the capacity of the state to address (Parry-Jones et al., 2001; Arlosoroff et al., 1987). The promotion of community participation and management approaches was also reflective of the political consensus at the time which sought to minimise the role of the developing country state in the provision of infrastructure, goods, and services (World Bank, 1981).

In the 1990s, the momentum behind the community based approaches continued. At the start of the decade, New Delhi hosted the influential Global Consultation on Safe Water and Sanitation. This conference reasoned that the local community ownership and management of water and sanitation systems, with appropriate oversight from capacitated local government institutions, would help guarantee a demand responsive provision of systems and in turn lead to the improved financial management and maintenance of assets (Robinson, 1993).

These core principles agreed at New Delhi were reaffirmed at the 1992 International Conference on Water and the Environment in Dublin alongside an additional principle that all stakeholders should treat water as an “economic good” to ensure more judicious and sustainable use of available resources (WMD, 1992).

In subsequent years, the interpretation of the “economic good” principle has become contested (Savenije and Van Der Zaag, 2002). According to Black (1998), understanding water as an “economic good” meant that a quantified value should be given to all its uses – this may be expressed in terms financial, opportunity or environmental costs – and should be factored into decision making. In the view of Perry et al. (1997) this phrasing was seen as a compromise between those economists that argued that water to be treated as a private good to be allocated by competitive pricing and those who maintained that water is a social good, and basic human need, that must be provided in a non-excludable manner. The instrumentalisation of this principle in the water sector has come to reflect this compromise - where on one hand water should be considered a vital social good, without substitute, that should be not be subject to unfetted market forces, while on the other hand recognizing that where possible it is important that water should have an economic “value” to both a) encourage the recover the costs of supply the service and b) emphasise that water is scarce resource that should be used judiciously (Van Der Zaag and Savenije, 2006).

In terms of water supply, one important emerging challenge is that of small town service provision. Small towns tend to be sufficiently large and dense for central areas to be served by a piped water supply with fringe areas served by traditional point sources (Adank, 2013; Pilgrim et al., 2007). It is argued that the management of piped systems require higher levels of planning, design, administrative, and technical capacity than point source systems, and this can often mean that community management approaches are inappropriate (Pilgrim et al., 2007; Moriarty et al., 2004). The different challenges of small town service delivery have led to adoption of a diverse range of alternative management and financing approaches with service delivery roles taken by private sector, local, municipal and national government actors (Adank, 2013; Pilgrim et al., 2007).

An additional approach rural water provision is that of self-supply. Self-supply refers to local projects undertaken by households or small grouping of households that take measures to provide construct, operate and maintain their own systems (Smits and Sutton, 2012; Kumamaru, 2011; Sutton, 2009 ). According to Lockwood and Smits (2011), the growth of self-supply options in the sector is a response to inadequate provision and sustainability of formal water systems.

Over the past 30 years a variety approaches to the provision and management of rural water and sanitation services have shifted from supply led to more demand responsive, community managed approaches. More recently still a variety of alternative financing and management models have emerged which have sought to adapt or replace community-management approaches in response to poor outcomes and in recognition of the fast-changing and diverse challenges of service provision amongst rural contexts. Having identified these broad trends the following sub-sections critically examine sector evidence in order to identify the key elements impact the sustainability of rural water and sanitation services.

### The supposed key "elements" of a sustainable service

The evolving global policy debates of how rural systems can be most sustainability managed and financed has led to various attempts to distil the key "elements" of sustainable water or sanitation systems in (WaterAid, 2011; Montgomery et al., 2009; Harvey and Reed, 2006; Lockwood et al., 2003; Parry-Jones et al., 2001; Carter et al., 1999; Arlosoroff et al., 1987).

Montgomery et al. (2003) identify three universal "sustainability components" of rural water and sanitation services that are broadly in line with the Delhi principles: effective community demand; some level of local financing and cost recovery; and dynamic operation and maintenance. Accompanying these components are 12 recommended actions to ensure these are met. These include: creating a community-based financial plan; selecting a technology based on local choice and socio-economic conditions, and providing training and ongoing support for financial planning.

WaterAid's "sustainability framework" for rural water, sanitation and hygiene services emphasises similar issues. The framework identifies 14 factors that underpin the achievement of functionally sustainable services. Each of these factors relate to one of four areas: effectively establishing demand for services; ensuring appropriate service design and implementation, sustaining an active and capacitated community management team, and ensuring that external agencies are able to support community-based organisations (WaterAid, 2011).

Carter et al. (1999) recognise the inter-linkages between sustainability elements. It is argued that community managed water and sanitation systems rely on a "sustainability chain" consisting of four components: the motivation of the community members to use the service over alternatives, the maintenance of the infrastructure ensuring the availability of spare parts, the recovery of service costs from community members, and continued support to communities outside project intervention cycles. Any break in this chain would endanger the functional sustainability of services.

The following sub-sections provide a more detailed analysis on these sustainability components based on available literature.

**Community management and external support**

Although there is no single approach to community management the reported common principles are thought be important (Scaling up Working Group, 2005). The community management team is meant to be inclusive, gender balanced and representative of a cross-section of residents. Communities should have a measure of control over system design and assume some responsibility for operation and maintenance and be free to make independent management decisions (Scaling up Working Group, 2005; World Bank, 1998). It argued that these factors are important, if not entirely sufficient, to help generate a sense of community ownership and responsibility towards sustained service delivery (WaterAid, 2011; Carter et al., 1999).

The “received wisdom,” of the sector is that community management and participation (particularly of the poor) is crucial to long term sustainability (Annis, 1987). In support of this reasoning, Sara and Katz (1998) found a statistically significant positive relationship between the sustainability of rural water systems and projects that ensured a demand responsive, participatory, community managed approach. Similarly Narayan (1995), in a study of 121 rural water supply project, across 49 countries identified a significant relationship between levels of community participation and the effectiveness of the project.

However, in response to the prevailing high rates of water system breakdown (RWSN, 2010; Haysom, 2006; Baumann, 2006; Evans, 1992), and abandonment of sanitation systems and sanitary practices (CMS, 2011; Rodgers et al., 2007; Cairncross and Valdmanis, 2006); the dominant paradigm of independent community managed services is starting be questioned (RWSN, 2010). Specifically the literature shows cases where the designated community WATSAN committee (or equivalent) have lack the sufficient technical, managerial, and economic capabilities to independently operate and manage schemes, even given initial training (Jha, 2007; WSP-AF, 2002; Kleeimeier, 2000).

It also argued that implementing agencies often overstate the capacity and commitment of community groups to operate and manage rural services and should not be taken for granted (RWSN, 2010; Jha, 2010; Harvey and Reed, 2006; Bagamuhunda and Kimanzi, 1998). Indeed the effectiveness of community management approaches have been found to be subject to a variety of internal and external influences.

From a behavioural perspective, Ostrom (1990) contends that the existence of shared norms and values within a community promotes more effective management of common pool resources. Nemarundwe and Kozanayi (2003) recognise aspects "institutional engineering" in community management approaches, where attempts are made to introduce a new form of local management structure into communities without adequate appreciation of existing community dynamics or decision-making structures. Over time this can inhibit participation and ultimately the management of services. Miguel and Gugerty (2005) focus on internal community dynamics as a factor in service delivery, finding that hand-pumps tended to perform much better in communities where there was less religious fractionalisation (diversity), elsewhere Lockwood et al. (2003) drawing on their experience in the water sector, contend that the effective participation can often just down to the presence of a "dynamic leader" within the community.

Jones (2011) examines external influences on the community, particularly the affect that national policy prescriptions have on the effectiveness and nature of community participation. Focussing on studies in rural Mali, he argues that the constant reinforcement of the message that users need to pay tariffs serves to undermine effective community engagement and ownership of service delivery. Participation is reduced to a transactional process termed "participation as payment", rather than the ideal "participation as citizenship" where communities feel ownership of water points and recognise a civic responsibility to maintain them.

In the sanitation sector, demand-creation programmes are seen as an effective way to galvanise communities and individual households to construct, maintain and use latrines (Waterkeyn and Cairncross, 2005). Individual households are the "key investors" in on-site sanitation systems (WHO, 2012), and as shown in a 6 country comparative study by Tremolet et al. (2010), stakeholder investment in community engagement and sensitisation (so called "software" activities) are found to be important motivators of household investment in latrine construction.

There are variety of well know approaches to sanitation (and hygiene) promotion that each employ different strategies for demand creation; these include community led total sanitation (Chambers 2009), participatory hygiene and sanitation transformation (Simpson-Hébert et al., 1997), and community health clubs (Waterkeyn and Cairncross, 2005). These approaches have been shown to encourage latrine construction (Pattanayak et al., 2007) and sustain hygienic behaviour changes as in Africa and Asia (Cairncross and Shordt, 2004) and The Gambia (Simms et al., 2005).

However Waddington et al. (2009) in a meta-analysis on the impact of sanitation and hygiene interventions, shows that longitudinal studies have not been conducted that can determine whether positive behaviour changes are actually being sustained over time. Indeed more recent evidence from an evaluation of CLTS programmes implement since 2001 showed that when factors such as latrine cleanliness and use were taken in account just 8% of latrines were considered functional - a slippage of 92% since 100% coverage was declared (Tyndale-Biscoe et al., 2013). Similarly, in Ethiopia Awoke and Muche (2013) found that over two thirds of latrines constructed as part of rural sanitation promotion were considered to be "non-functional" due to issues of cleanliness and maintenance.

Ross et al. (2011) recognise that often latrine use was sustained up until the latrine became full, but after this point the latrine was not rebuilt and households reverted to traditional practices. It is therefore argued that for sanitation behaviour change to be sustained ongoing “software” support needs to be provided to households (Tyndale-Biscoe et al., 2013; Awoke and Muche, 2013).

Ensuring that the community organisation received ongoing institutional support is repeatedly cited as a key element of sustainability in section 2.7 (WaterAid, 2011; Montgomery et al., 2009; Carter et al., 1999). This is premised on the belief that periodic and systematic institutional support in the form of sensitisation and training (“software”) will help keep communities motivated, trained, and integrated within wider maintenance and supply chain networks (RWSN, 2010).

Emerging evidence supports this view. A comprehensive four country review of WaterAid projects concluded that on-going support is key factor in increasing the longevity and resilience of community management bodies (Blagbrough, 2001). Prokopy et al (2008) in a multi-village case study in rural Peru found that villages that have access to external technical support are more likely to undertake operational and capital repairs than those that are unable to access support. Similarly, ongoing technical support by trained “circuit-riders” was linked to improved community administrative and maintenance performance in El Salvador (Kayser et al., 2010). In Uganda community managed water systems with external support available enjoyed greater functionality and longevity (Carter and Rwamwanja, 2006).In relation to small towns a review of community managed piped systems in Ethiopia, Malawi and Kenya found that systems were more vulnerable to management failure when professional and technical support networks are not in place (WSP-AF, 2002; see also Kleeimeier, 2000).

The WASHCost “life-cycle cost” framework captures these wide-ranging support activities under the heading expenditure on “direct support” (Fonseca et al., 2011). Direct support is an umbrella term for a set of activities including technical advice; service monitoring; administrative and managerial support; conflict resolution; and fund mobilisation (Fonseca et al., 2011). The evidence base on the importance of direct support seems to be building – but to the authors knowledge no studies have yet to quantify the cost effectiveness of different models of support. Moriarty et al. (2013) speculate that the relationship between expenditure on support and service outcomes is unlikely to be linear. The impact of direct support is instead likely to be subject to threshold effects, whereby below a certain level of direct support expenditure there will be no measurable impact on service delivery until the threshold is reached.

In both water and sanitation interventions it is recognised that effective demand generation and community participation represents good practice and can contribute to more effective projects and sustained outcomes. Nevertheless, in the case of rural water projects, community participation should not be taken for granted as a variety of social and cultural factors can influence effective community engagement and management. In the case of sanitation projects demand creation activities are shown to be effective in stimulating household investment in latrines, although at this stage it remains uncertain whether infrastructure and practices are being sustained. In both cases there is emerging evidence that if community ownership and participation are to be sustained, some form of ongoing support is required to bolster local management, administrative, and technical practices, as well as ensuring ongoing "software" investment to sustain behaviour change.

**Decentralisation**

A corollary to the direct community management of services has been the widespread decentralisation of water and sanitation governance to local government agencies with the aim of raising the quality, demand-responsiveness and accountability of service delivery (Robinson, 2007; World Bank, 2003; Colin and Morgan, 2002) and improve opportunities for the sustainable recovery of costs (OEDC, 2009; Van Hofwegen, 2006; Winpenny, 2003).

Decentralisation refers to the transfer of public functions from higher tiers to lower tiers in governance (Jütting et al., 2005) and can take many forms (Smits et al., 2011) including: administrative decentralisation - the devolution of staff and functions to the local level; financial decentralisation – the transfer of funds and revenue generating powers; political decentralisation – the devolution of decisions making powers; or a combination of any of the above approaches

(Jha, 2010). As Smits et al (2011) recognise, no two decentralisation processes are the same, and therefore institutional arrangement's role will change from country to country and also between rural and small town areas. Lockwood and Smits (2011), recognise that over the last two decades "almost all" developing countries have implemented broad decentralisation processes, transferring health, education and WATSAN governance functions to local levels; in relation to water supply they outline examples of decentralisation in: Benin, Burkina Faso, Ethiopia, Ghana, Honduras, India, Mozambique, South Africa, and Uganda.

Under decentralised management local councils and municipal governments often play a linking role between line ministries and donors and community-based organisations. Schouten and Moriarty (2003) define this role as a "service authority". Prominently these processes have divided service authority functions (planning, monitoring, post-construction support, and oversight) fulfilled by government agencies from direct service provider functions assumed by community organisation, private operators, and households (Lockwood and Smits, 2011).

Frost (2012), however, argues that the near ubiquitous promotion of decentralised/community based approach has meant state capacity, and liability, for service provision has been weakened. Accordingly local government agencies often do not have the financial or human resource capacity to fulfil their devolved functions and community organisations are left isolated from wider financial and technical support networks (Mehta and Mehta, 2008; Robinson, 2007). Expanding on this theme Lockwood and Smits (2011) argue that the capability of community organisations to operate and manage services should not be viewed in isolation from the direct support they receive from the service authority, and in turn the capability of the service authority to provide this support is also linked to relationships with central government ministries and donor organisations.

Despite its prevalence there is little evidence that suggests that decentralisation of service delivery has resulted in improved outcomes (Conyers, 2007) and its validity still needs to be proven (Robinson, 2007). From the author's own experience and in accordance with the ideas forwarded by Lockwood and Smits (2011); Mehta and Mehta (2008); and Robinson (2007) the effectiveness of decentralised maintenance, management, and monitoring of infrastructure can rarely be separated from broader institutional resource and capacity issues. Even in the case of fairly self-directed service delivery approaches, such as self-supply, the validity and success of service are dependent on a number of indirect enabling factors such as private sector capacity and supportive national policies (Sutton, 2009).

This echoes the sustainability frameworks of Carter et al. (1999) and Parry-Jones et al. (2001) where rural service delivery is envisaged a series of interdependent links in chain. A weakness in one link can threaten the functional sustainability of the entire service delivery model. According to Carter et al. (1999) another important link in the service delivery chain is the capability of service providers ensure that the costs of operating, maintaining and rehabilitating are met.

For self-initiated approaches, such as household self-supply, the direct costs of construction maintenance and renewal tend to be entirely covered by a household or a group of households (Sutton, 2009). For such systems to be affordable it is important that there is a good fit between the sophistication of the technology, the user's willingness and ability to finance all maintenance and management costs, and the aspirations of what users demand for services.

Conversely, within "externally-driven" approaches - defined as those driven, financed, and/or supported by government and donor agencies external to the user group/communities and very common in developing countries – there is an expectation that the costs will be shared amongst different agencies (Cranfield University, 2006).

The opening section of the literature review has demonstrated that achieving sustainable water and sanitation services in rural areas is contingent of a number of inter-dependent factors. It has also demonstrated, through the identification of high asset breakdown rates, and the limitations of various approaches, that achieving sustainability remains a great challenge within the sector and no single approach to service delivery can be considered




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appropriate in all contexts. Various models of rural service delivery and financing have been discussed. Over the past three decades the most prominent mode of service delivery has been through the community ownership, management, and financing of services. However the diverse challenges of delivering services in rural and small town areas means a variety of different approaches and models of service delivery are being explored, each with different approaches to cost-sharing and financing. Fundamentally it is argued that in all service delivery approaches, long term functionally sustainability can only be achieved if asset maintenance and renewal activities are must take place and these costs of these need to be budgeted and accounted for by sector agencies, often through cost sharing arrangement

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# Appendix B Database search for cost data

Two database searches of SCOPUS were undertaken, one to access literature on water costs, and one to access literature on sanitation costs. The terms of the search queries are shown below and details of the literature accessed are shown in Table 7-1 and Table 7-2.

## B.1 1. Water

**Search term (title):** "water supply", cost

**Search term (title - abstract - keyword):** AND rural

**Search term (title - abstract - keyword):** OR developing country, OR low income

**Limits:** Search limited to article, reviews or book chapters

**Advanced search query:** (TITLE("water supply") AND TITLE(cost) AND TITLE-ABS-KEY(rural) OR TITLE-ABS-KEY(low income) OR TITLE-ABS-KEY(developing country)) AND ( LIMIT-TO(DOCTYPE,"ar" ) OR LIMIT-TO(DOCTYPE,"re" ) OR LIMIT-TO(DOCTYPE,"ch" ) )

**Results:** 25 documents found. Two provided empirical data on the financial costs of rural/small water supply systems, 1 provided an estimate of costs.

## B.2 2. Sanitation

**Search term (title):** sanitation, cost

**Search term (title - abstract - keyword):** AND rural

**Search term (title - abstract - keyword):** OR developing country, OR low income

**Limits:** Search limited to article, reviews or book chapters

**Advanced search query:** (TITLE(sanitation) AND TITLE(cost) AND TITLE-ABS-KEY(rural) OR TITLE-ABS-KEY(low income) OR TITLE-ABS-KEY(developing country)) AND ( LIMIT-TO(DOCTYPE,"ar" ) OR LIMIT-TO(DOCTYPE,"re" ) OR LIMIT-TO(DOCTYPE,"ch" ) )

**Results:** 22 documents found. Two provided empirical data on the financial costs of sanitation systems.

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**Table 7-1: Scopus search results on water costs**

| Authors | Title | Year | Source title | Type of study | Cost data | Any comments or cost details |
|---|---|---|---|---|---|---|
| Rudra Narsimha Rao G., Nand Gopal E., Sharma K.V. | Cost effective solution for energy efficiency in urban water supplies: Developing countries | 2014 | International Journal of Applied Engineering Research | Urban utility | Yes | Not relevant |
| Dharmaratna D., Parasnis J. | An analysis of the cost structure of water supply in Sri Lanka | 2012 | Journal of the Asia Pacific Economy | Urban utility | Yes | Not relevant |
| Fahimuddin | Drinking water collection and cost-benefit analysis of a rural water supply scheme in Uttarakhand State | 2012 | Journal of Rural Development | Health and economic | No | |
| Pindihama G.K., Gumbo J.R., Oberholster P.J. | Evaluation of a low cost technology to manage algal toxins in rural water supplies | 2011 | African Journal of Biotechnology | Technical (urban water treatment) | Yes | Not relevant |
| Van Halem D., Heijman S.G.J., Johnston R., Huq I.M., Ghosh S.K., Verberk J.Q.J.C., Amy G.L., Van Dijk J.C. | Subsurface iron and arsenic removal: Low-cost technology for community-based water supply in Bangladesh | 2010 | Water Science and Technology | Technical (water treatment) | No | |
| Hunter P.R., Pond K., Jagals P., Cameron J. | An assessment of the costs and benefits of interventions aimed at improving rural community water supplies in developed countries | 2009 | Science of the Total Environment | Health and economic | No | |
| Jeuland M., Whittington D. | Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs | 2009 | Vaccine | Health and economic | No | Cost estimates for point source systems - not shown to be evidence based |
| MacRae Jr. D., Whittington D. | Assessing Preferences in Cost-Benefit Analysis: Reflections on Rural Water Supply Evaluation in Haiti | 2009 | Cost-Benefit Analysis and Public Policy | Health and economic | No | |
| Mara D., Alabaster G. | A new paradigm for low-cost urban water supplies and sanitation in developing countries | 2008 | Water Policy | Conceptual | No | |
| Hutton G., Bartram J. | Global costs of attaining the Millennium Development Goal for water supply and sanitation | 2008 | Bulletin of the World Health Organization | Health and economic | No | Based on old data |
| Hutton G., Haller L., Bartram J. | Global cost-benefit analysis of water supply and sanitation interventions | 2007 | Journal of Water and Health | Health and economic | No | Based on old data |
| Sauer J., Frohberg K. | Allocative efficiency of rural water supply - A globally flexible SGM cost frontier | 2007 | Journal of Productivity Analysis | Urban utility (devloped world) | No | |
| Virjee K., Gaskin S. | Fuzzy cost recovery in planning for sustainable water supply systems in developing countries | 2005 | Energy | Urban utility | No | |
| Jaglin S. | The right to water versus cost recovery: Participation, urban water supply and the poor in sub-Saharan Africa | 2002 | Environment and Urbanization | Conceptual | No | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Wright J.C., Bates M.N., Cutress T., Lee M. | The cost-effectiveness of fluoridating water supplies in New Zealand | 2001 | Australian and New Zealand Journal of Public Health | Technical (urban water treatment) | No | |
| Ilahi N., Grimard F. | Public infrastructure and private costs: Water supply and time allocation of women in rural Pakistan | 2000 | Economic Development and Cultural Change | Health and economic | No | |
| Tang M., Fan Y., Wang G. | Comprehensive cost-benefit evaluation for the improvement of rural water supply in Hunan province | 1996 | Chinese journal of preventive medicine | Health and economic | No | |
| Schur M.A. | Cost of rural water supply: a case study in South Africa | 1994 | Water SA | Financial costs | Yes | Cost of small piped system in South Africa service approx. 1,000 people, Capital expenditure (Rand): 173 per capital 1989 prices. Found cost of community participation was significant at 41% of total project cost. |
| Watts R. | Low-cost water supplies and their contribution to health. | 1992 | Africa health | Health and economic | No | |
| Katko T.S. | Cost recovery in water supply in developing countries | 1990 | International Journal of Water Resources Development | Cost-recovery | No | Very relevant discussions on types of costs and challenges of financing |
| Pinfold J.V. | Faecal contamination of water and fingertip-rinses as a method for evaluating the effect of low-cost water supply and sanitation activities on faeco-oral disease transmission. I. A case study in rural north-east Thailand | 1990 | Epidemiology and Infection | Health and economic | No | |
| Zoppis L., Zoppis R. | Cost of Groundwater Exploration for Rural Water Supply Projects in Developing Countries | 1989 | Developments in Water Science | Financial costs | Yes | Costs of constructing hand-dug well in developing countries. Cost $500 per productive well to $2000 for drilled well with handpump (1989 values) |
| Arlosoroff S., Roche R., Wright F. | Economic Considerations for Low-Cost, Groundwater-Based Rural Water Supply | 1989 | Developments in Water Science | Economic assessment | No | |
| DANIELS K.E. | Existing legislation covering the cost or rural sewerage and water supply and connecting regulations and amendments considered desirable thereto. | 1954 | Journal. Royal Sanitary Institute (Great Britain) | Legal | No | |
| [No author name available] | The Lancet Special Commission on the water supply and disposal of sewage. Being an Inquiry Supplementary to a Recent Commission on the Relative Efficiency and Cost of Plumbers' Work | 1899 | The Lancet | Misc. | No | |

**Table 7-2: Scopus search results on sanitation costs**

| Authors | Title | Year | Source title | Type of study | Cost data | Any comments or cost details |
|---|---|---|---|---|---|---|
| Van Dijk M.P., Etajak S., Mwalwega B., Ssempebwa J. | Financing sanitation and cost recovery in the slums of Dar es Salaam and Kampala | 2014 | Habitat International | Financial | Yes | Cost of latrines in urban areas: CapEx range from $222 - to $318 in Kenya; Capital maintenance between $44.46 to $69.87 through different emptying methods |
| Gunther I., Fink G. | Saving a life-year and reaching MDG 4 with investments in water and sanitation: A cost-effective policy? | 2013 | European Journal of Development Research | Health and economic | No | |
| Bartram J., Charles K., Evans B., O'hanlon L., Pedley S. | Commentary on community-led total sanitation and human rights: Should the right to community-wide health be won at the cost of individual rights? | 2012 | Journal of Water and Health | Health and economic | No | |
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| | | | | | | |
|---|---|---|---|---|---|---|
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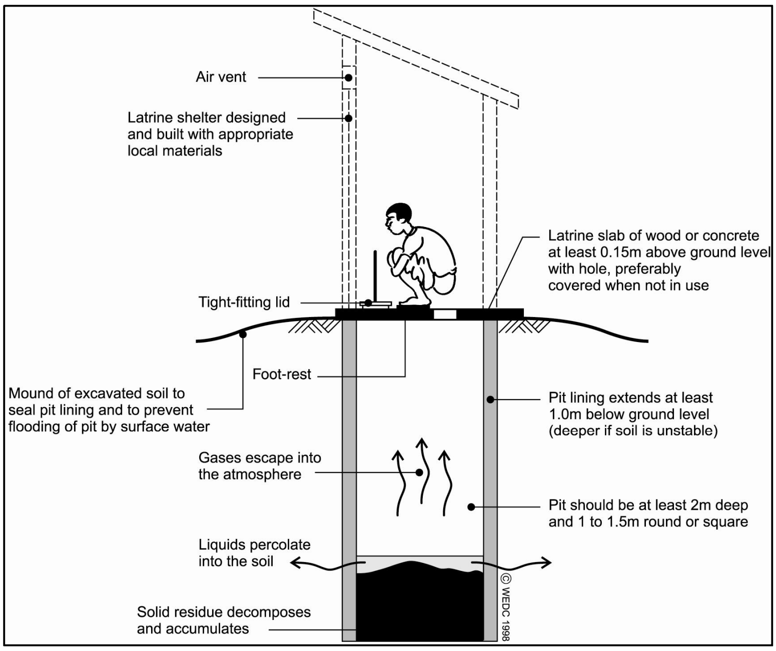
# Appendix C Supporting information methodology

## C.1 Latrine technologies

### Figure 7-1: Traditional / improved pit latrine (depending on the wood / concrete slab)




Source: Rod Shaw (2013)

### Figure 7-2: Rudimentary pit latrine Mozambique

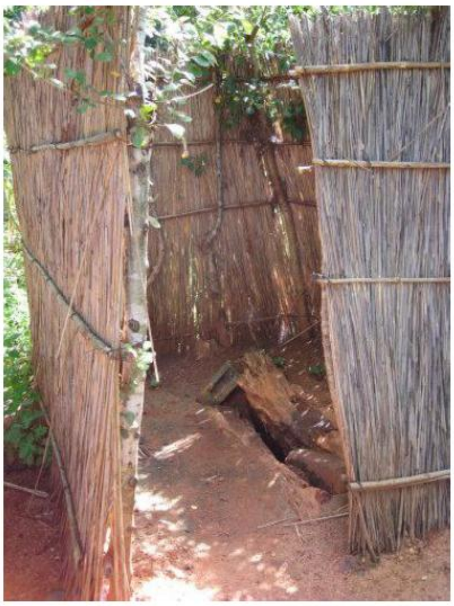
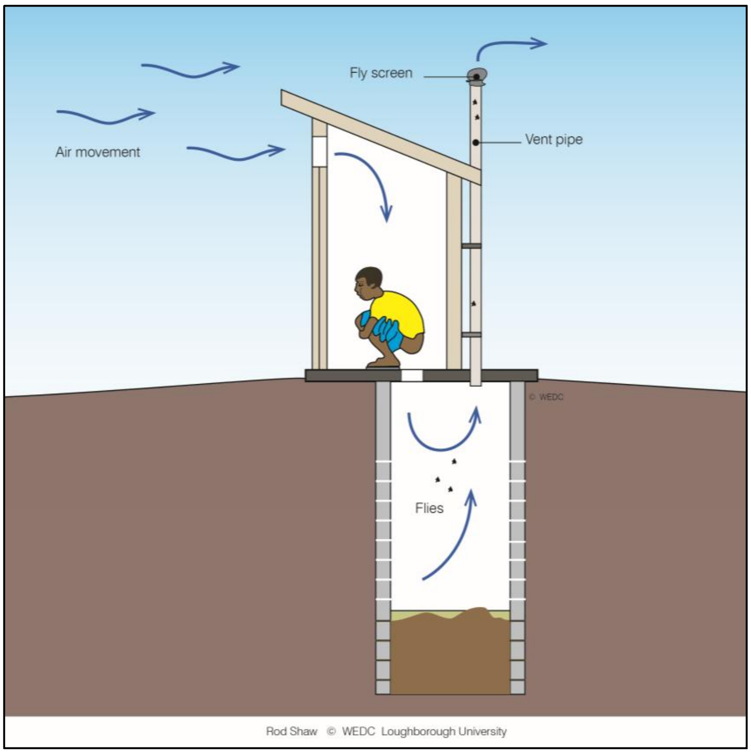


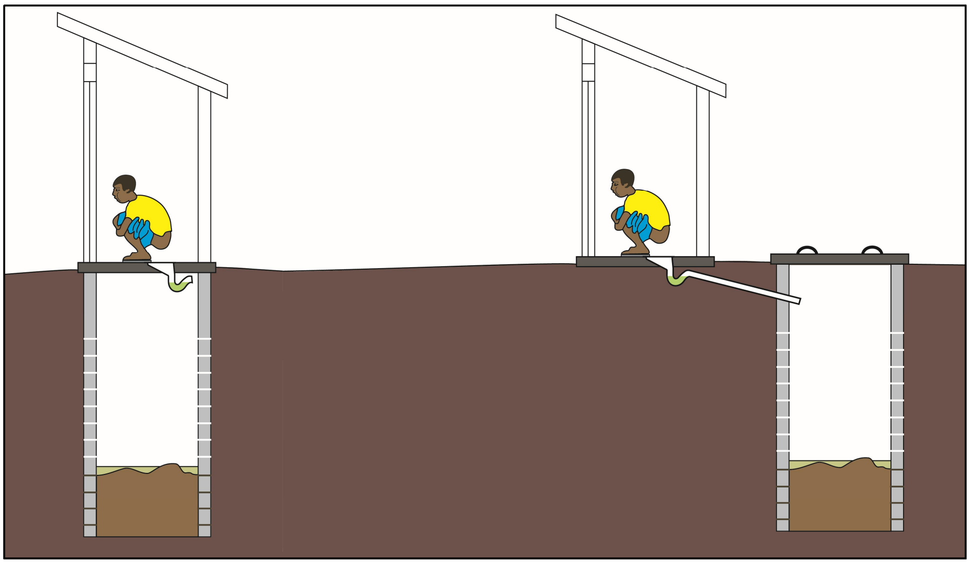
**Photo credit: Peter McIntyre**

**Figure 7-3: Ventilated improved pit latrine**



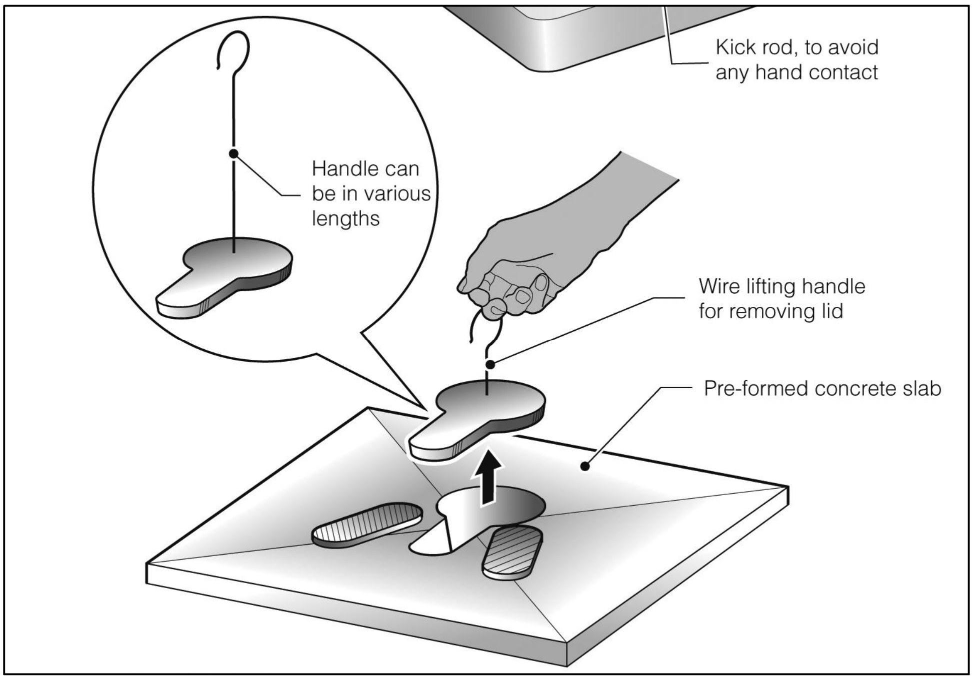

Source: Rod Shaw (2013)

**Figure 7-4: Pour flush (single pit)**



Source: Rod Shaw (2013)

**Figure 7-5: Pre-form concrete slab**



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## C.2 Data collection methodology Sierra Leone

### Table 7-3: Overview of data collection activities in Sierra Leone

| Research area | Research tool | Information accessed | Sample size | Timeline |
|---|---|---|---|---|
| Determining the life-cycle costs and service levels of water supply | Household survey Water | - Expenditure per household (CapEx, OpEx, CapManEx)<br>- Water service level per household (Access, Quantity, Quality, Reliability) | 30 rural communities sampled - 900 household surveys were undertaken 30 for each rural community. | Sept – Oct 2013 |
| | Water management team interview + facility mapping | - Core community and water point information.<br>- Community expenditure records (OpEx and CapManEx)<br>- Water point reliability (quantitative information) | A single interview undertaken in each community with either the Water Management Team (WMT), or if this team does not exist interview were conducted with community leaders responsible for maintaining facilities. | Sept – Oct 2013 |
| | District data collection | - Assessment of district activities to support community water management + estimated or actual annual expenditure - including salaries (ExpDS)<br><br>- Examining district expenditure on repair/rehabilitation and construction (if applicable) of water point systems over the previous 3 years. | Detailed interviews were conducted with the district council water team to document a) examples of district support over the last year b) estimate or actual cost of running the department annually (including salaries)<br><br>In addition collaborative work with district council finance department delivered evidence of district expenditure on water point repair and rehabilitation. | Oct – Nov 2013 |
| Determining the life-cycle costs and service levels of sanitation and hygiene interventions | Household survey (sanitation and hygiene) | Household hygiene service level related to: 1) Faecal containment and the use of a latrine, 2) Hand washing with soap or substitute at critical moments, 3) Safe water-source and management at household level.<br><br>- Financial and economic costs incurred by households on sanitation and hygiene activities before, during and after the CLTS intervention. | A total of 723 household surveys were conducted across 20 communities Port Loko and Kenema districts. Baseline and endline surveys were conducted in the 4 communities that underwent a CLTS intervention during the timeline of the WASHCost project. The remaining 16 communities had been subject to a CLTS intervention with the past 4 years and provided an insight into whether sanitation and hygiene practices are being sustained. | Sept – Oct 2013 |
| | Data collection from implementing partners | A detailed breakdown of the cost incurred in rolling out and supporting specific sanitation and hygiene programmes. | Data collected from the major implementing partners | Sept 2013 to January 2014 |
| Small study on the life-cycle costs and service level of self-supply technologies | Household survey | Household life-cycle cost expenditure on self-supply technologies and service levels received. | 19 households with self-supply systems interviewed in Kenema district. | Dec – 2013 |
| | Focus group discussion with self-supply technicians | Cost ranges and drivers for different self-supply technologies. | 1 discussion attended by 8 self-supply technicians in Kenema district | Dec – 2013 |

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The group of enumerators and research officers chosen to carry out the study received initial training and orientation on the methodology and research tools from the WASHCost Sierra Leone project team. Training was focused on the household surveys since this data will be collected using android mobile phone technology on an open data collection platform, which might be unfamiliar users.

Training will took place over two consecutive days bringing together the consultant's data collectors and district council staff. Community data collection took 7 working days in each of the districts.

Table 7-4 shows the study districts and the final number of households to be surveyed in terms of water and sanitation/hygiene.

**Table 7-4: WASHCost study District Councils and number of communities/surveys**

| **District** | ***BO (Only water surveys)*** | ***Kenema (Both water and sanitation)*** | ***Kambia (Only water surveys)*** | ***Port Loko (Only sanitation)*** |
|---|---|---|---|---|
| Water Surveys | 10 communities served by point source systems (300 surveys) | 10 communities served by point source systems (300 surveys) | 10 communities served by point source systems (300 surveys) | |
| Sanitation surveys | | 8 communities in total<br>- 4 classified as being open defecation free<br>- 4 having recently been the subject of a community led total sanitation intervention.<br>(360 surveys) | | 8 communities in total<br>- 4 classified as being open defecation free<br>- 4 having recently been the subject of a community led total sanitation intervention.<br>(360 surveys) |

*Household water supply survey (survey code (HH – Water)*

Each community in the sample will vary in land area, population size and population density. Therefore to capture a more accurate impression of the water services in the community the data collection team will undertake the following actions:

1) Engaged local leadership to gain an understanding of where community boundaries are;

2) Used this knowledge, segment the communities into 3 roughly equal portions for rural communities;

3) Divide the number of household surveys equally between these segments (e.g. 10 in each).

In communities where there are only a small number of households (<30 for rural communities) this segmentation did not take place.

Each household questionnaire was designed and tested during training and piloting so it took no longer than 30 minutes to complete. The training was also an opportunity to go through each question in the household surveys and translate it into the appropriate local language to ensure the fidelity of the question is maintained.

Data will be collected and stored using Android mobile phone technology. The team will be orientated around this technology as part of the training.

*Water management team interview + facility mapping (survey code: W –FM)*

This aspect of data collection is dependent on identifying a small number of key informants from each sample community. In rural areas community water management teams have responsibility for the day-to-day maintenance and management of water systems and are therefore considered the default key informants about the general WASH services within the community. In some communities a WMT will not exist and a small number community leaders will have to be identified as key informants. The community should have been contacted ahead of the site visit to determine that identified key informants will be available and that appropriate documentation will also be made available.

This survey aims to capture general information about the community water services and management as well as specific information on water point location and costs. This will require good co-operation and engagement of the WMT/Community leaders.

Community information: This includes size (number of people or population), economic activity of residents, and number of people accessing formal water points (wet season and dry season).

Water cost and service information: Summary list of number and types of facilities in the community accompanied by more detailed examination of facility location, age, cost of construction, reliability and maintenance history.

It is recommended that initially the summary of water facilities in the communities should be completed. Subsequently the core information of each facility can be discussed in turn with enumerators noting relevant information in the "Overview of water point location matrix" and the "water point data matrix" throughout the discussion.

At the end of this the process the data collection team should come together and make sure they all understand the location of water point facilities in the community and assign an agreed code to each water point. Using this information the supervisor should segment the community (in the manner described above, see the section "1) household survey – water supply cost and service") and assign enumerators to each area.

*<u>District data collection (for water) (Survey code W-DCS)</u>*

As part of the study of water costs, data on expenditure on direct support and capital maintenance expenditure needs to be collected from Bo, Kenema and Kambia district councils.

Senior members of the data collection team or those with best links with the district councils are best placed to collect this information.

This survey at the District Council has two components

- A one-off detailed interview with district council water team to document:

a) Examples of district water, sanitation and hygiene support given to communities and small town areas over the last year

b) Estimate or actual cost of running WASH department activities annually (including salaries).

Working with the district council finance department to gather evidence of district expenditure on repair/rehabilitation or construction of water systems over the last three years. This will need co-operation and approval of the district finance officers.

It is expected that both these components should not take more than a single day spent at the district council - provided that the data collection team has effectively co-ordinated with district officials to make sure they are ready for the visit and have appropriate documentation to hand. **Please note:** This survey must be supervised and not simple handed to council staff that are not familiar with the goals, terminology and concepts of WASHCost Sierra Leone.

*General guidelines for community entry and household surveys*

It is important that the data collection team undertakes the necessary steps to be sensitive to the local cultural context and work with the permission of ward councillors as well as community and district leaders.

The WASHCost SL team has at least one focal person in each of the district councils in the study and these should be used to ensure that the correct procedure is followed.

The mandatory actions that should be taken before data collection begins are:

- Ensure permission from the relevant ward councillors making sure the purpose, scope and dates of the data collection are explained. It should be stressed that the time spent in the community will be relatively short (no more than 1 day) and that the District Council is aware of the scope of the study.
- Through district contacts, ensure that a member of the community WMT or community leaders are given adequate notice (at least 2 days, but over a week is preferred) prior to community entry about the purpose, scope and dates of potential data collection. This is also an opportunity to re-affirm that the community is happy to participate and emphasize that all data collected is confidential so responses cannot be traced back to a single household.

- Re-confirm arrangements for data collection with community leaders the day before departing to the community and prompt the community to make sure any records or documentation they have about the system are made available.
- Ensure adequate materials are available to you: the questionnaires are uploaded onto the phone, sufficient copies of the paper based surveys are printed off and the team has appropriate materials (e.g. clip-board, pens etc.).

*Community ethics – during data collection*

- Within the community, interviews conducted with the Water Management Team or community leaders should be led by the field team supervisor
- Each participating household should be assured that all data collected is confidential so responses cannot be traced back to a single household.
- Inform the household that data is being collected for a research project. It should be stressed that this is a research project and does not have any scope for infrastructure investment.
- If the household head or leader (preferably the female leader) is not available or the enumerator has any other reasonable judgment that a particular household member may not be a reliable respondent – move on to the next household in accordance with the sampling strategy.

*Defining a household*

In this study a household is defined as a nuclear or "smaller" family (not including the extended family) who share meals and utilise water from the same pot. Typical examples are:

- A father and mother with 5 children all living together most of the time.
- A widow with 2 kids all living together most of the time.

*Selecting a respondent*

The household survey enumerator should try to ensure that the household respondent is an adult female (18 years and above) who could be the

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breadwinner, household head, mother, caretaker or any responsible member (sibling, daughter, nieces, etc) of that household in a position to respond on behalf of the household. Females are the preferred candidates as respondents because traditionally they take responsibility for water, sanitation and hygiene related issues in the home and are therefore in a better position to give good account of prevailing circumstances. If no female respondent is available, then an adult male can be a candidate.

*Surveys*

**Table 7-5:** ***Household survey–Water (HH-Wat)***

| | |
|---|---|
| Form No: | Date of survey: |
| Interviewer (name/code): | Community name/code: |
| District council: | |
| **Respondent and Household** | |
| **1.** Does your household use any **formal water sources** in the community?<br>**(1)** Yes **(2)** No [if No, no household survey is carried out, END it here] | |
| **2.** Respondent's gender Male **(1)** Female **(2)** | |
| **3.** Respondent's age. ……………………… | |
| **4.** Who is the main household breadwinner? (*main person financing the home*)<br>(1) husband (2) wife (3) mother (4) father (5) other sibling | |
| **5.** What is the household income in a month/week? Le:………….. per (1) week (2) month | |
| **6.** How many (people) are you as a household? (*not entire compound or shared house members*): …………………….. | |
| **7.** What is the main religion of your household?<br>(1) Christianity<br>(2) Islam<br>(3) Traditional<br>(4) Other specify ……………………………………………<br>(5) None/non-religious | |
| **8.** What is the educational level of the main household breadwinner?<br>primary (1) junior secondary/high (2) senior secondary/high (3) Tertiary (4) | |

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**FORMAL WATER SUPPLY**

**9.** What is the main water source for your household?
(1) Hand-dug well with handpump
(2) Borehole with handpump
(3) Protected spring
(4) Public standpipe
(5) Tap inside house (House connection) (If this go to Q10)
(6) Tap in compound (yard tap) (If this go to Q10)

**10.** If **Q8** is **not house connection**, then which formal water point does your household mostly use?

(1) PS1 (2) PS2 (3) PS3 (4) PS4 (5) PS5

| | | |
|---|---|---|
| **11.** How much (quantity) water is fetched from this formal water source in a day for domestic uses? (in litres) | <u>Wet season</u> | <u>Dry season</u> |

**12.** Does the household access other formal sources for domestic uses? (1) Yes (2) No

**13.** If Q11 is Yes, which formal water source is this?
(1) Hand-dug well with handpump
(2) Borehole with handpump
(3) Protected spring
(4) Public standpipe
(5) Tap inside house (House connection)
(6) Tap in compound (yard tap)

**14.** How many days in a week do you use this other formal sources?
(1) Once a week (2) twice a week (3) thrice week (4) 4 days/ week
(5) everyday

**15.** How much (quantity) water is fetched from **this other** formal water source in a typical day? (in litres)

Wet Season____________________ Dry Season ________________________

**16.** What are the domestic water uses of these formal water source by your household?

**(1)** drinking only **(2)** cooking only **(3)** drinking/cooking

**(4)** other domestic chores (except drinking/cooking) **(5)** all domestic purpose

**17.** How much does your household spend on all formal water *for domestic uses only*?
Le …………per (1) day (2) week (3) month (4) adhoc

**18.** What is the household impression about the water tariff? **(1)** High **(2)** Acceptable **(3)** Low

**19.** Does your household use the formal water sources for any productive purposes? (1) Yes **(2)** No

**20.** If **Q19** is YES, then what are the productive water uses? (tick those applicable)

(1) food vending/canteen (2) salon (hairdressing) (3) local processing (4) watering animals (5) watering plans on farm (6) other …………………………..

**21.** How much (quantity) of water is accessed for productive uses?

Litres ……………per (1) day (2) week (3) month

**22.** Is your household satisfied with the quality of water from the main water point source accessed?

(1) *YES* ***(2)*** *NO*

**23.** If **Q22** is **No**, then why not? (tick those applicable)

**(1)=** has bad taste **(2) =** has unpleasant odour **(3)=**it is turbid **(4)**=has a salty taste **(5)**= other (specify)………

**24.** How reliable is the main formal water source used by your household?

**(1)** works all the time

**(2)** works most of the time, occasional breakdowns are quickly fixed

**(3)** works only some of the time, suffering from prolonged breakdowns

**(4)** works only seasonally (it fails consistently during the dry season)

**(5)** has broken down and has never been repaired

**25.** How long does it take to make one round trip to fetch water from the main formal water source? ………….. minutes

**Informal /alternative water sources**

**26.** Does the household use any other water apart from the formal water sources?

(1) Yes (2) No [if No pick GPS of household and end survey]

**27.** If **Q26** is **Yes**, which alternative water source is mostly used?
(1) open well /hand-dug well [if this >>> Q28]
(2) open well/ hand-dug well with rope and bucket [if this >>> Q28]
(3) rivers/streams/dams/ponds/lakes
(4) unprotected spring
(5) sachet water
(6) bottled water
(7) rainwater [if this >>> Q29]
(8) other ……………………………………………

**28.** Who owns your alternative water source?
(1) my household
(2) the landlord/lady [if this >>> Q30]
(3) the community [if this >>> Q30]
(4) an individual in the community [if this >>> Q30]
(5) not sure [if this >>> Q31]

**29.** How much did it cost to invest/provide the water facility? Le ………………, year : ……………

**30.** How much money did you contribute as a household? Le ………………, year : ……………
( ) Nothing ( ) don't remember

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**31.** How often do you use the alternative water source (days in a week)?
(1) everyday
(2) every other day
(3) twice in a week
(4) thrice in a week
(5) four days in a week
(6) once a week
(7) erratic
(8) not sure

**32.** What do you use the water from the alternative source for?

**(1)** drinking only **(2)** cooking only **(3)** drinking and cooking only

**(4)** other domestic chores **(5)** all domestic uses **(6)** productive uses only

**(7)** all domestic and productive uses

**33.** How much (quantity) of water is used from alternative source in a day (in litres)?

Wet season: ……………. Litres Dry season: ……………. Litres

**34.** Does the household spend any money on using the alternative water source? (1) Yes (2) No

**35.** If **Q34** is Yes, how much is spent on the informal water source?
Le …………….. per (1) day (2) week (3) month

**Household water treatment**

**36.** Does the household currently treat your drinking water?
(1) Yes, all the time
(2) Yes, sometime
(3) Yes, but erratic
(4) No

**37.** If **Q34** is Yes, what form of treatment is used?
(1) Chlorination
(2) Filtration with a ceramic device (such as a clay pot, or a candle filter)
(3) Filtration with a bio-sand filter
(4) Filtration with a filter cloth
(5) Solar disinfection
(6) Boiling
(7) Chemical coagulant (such as aluminum salt or iron salt)
(8) Other (Specify) ……………………………………..

**38.** Does your household spend any amount on the water treatment? (1) Yes (2) No

**39.** If **Q38** is Yes, then how much do you spend?

Le: ………………...per (1) day (2) week (3) month (4) adhoc

**GPS Location of House/Household**

| Northern/Eastern | Western/Southern |
|---|---|

**Table 7-6: Household survey sanitation and hygiene (HH – S&H)**

| | |
|---|---|
| Enumerator name or code: | District Council: |
| Community/town: | House (hold) number |
| **Respondent & household composition** | |
| **1.** Sex of respondent | (1) Female (2) Male |
| **2.** Age of respondent | |
| **3.** Name of household head | |
| **4.** What is your household size? | |
| **5.** How many household members are adults? | |
| **6.** How many household members are children above 5 years? | |
| **7.** How many household members are 5 years and below? | |
| **Access to sanitation** | |
| **8.** Do you have a latrine (toilet facility) in your house/compound? (1) Yes (2) No If NO go to question 24 | |
| **9.** What type is the household latrine (ask for description and also observe)<br>(1) Flush (WC/ Pour) to septic tank<br>(2) Flush to pit (latrine)<br>(3) Flush to somewhere else<br>(4) Ventilated Improved Pit latrine (VIP)<br>(5) Pit latrine with slab (impermeable slab, e.g. sanplat)<br>(6) Pit latrine without slab/open pit (e.g. traditional pit latrine)<br>(7) Composting toilet<br>(8) Bucket/pan latrine<br>(9) Hanging toilet/latrine is a toilet built over a water body (e.g. sea/river)<br>(10) Bush or field or open defecation or no facilities | |
| **10.** If **Q8** is Yes, who constructed the toilet facility?<br>(1) the household [if this go >>> Q10]<br>(2) landlord/lady [if this go >>> Q15]<br>(3) another tenant [if this go >>> Q15]<br>(4) not sure /don't know [if this go >>> Q15] | |
| **11.** If your household constructed the toilet facility, did you spend any money?<br>(1) Yes, we spent cash only<br>(2) Yes, we spent some money and used our own materials<br>(3) Yes, we spent money, used our materials and our labour<br>(4) No, we neither paid nor contributed anything [if this go >>> Q14] | |
| **12.** If household spent cash, how much was it and when?<br>Cash: Le …………………., Year …………………………… ( ) Don't remember | |

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**13.** If your household contributed materials, can you list them?
(1) Pot/bowl/seat
(2) pipes
(3) blocks
(4) cement
(5) slab
(6) roofing sheet
(7) wooden boards
(8) sand
(9) other (please specify) ……………………………………

**14.** If your household contributed labour, how many man (full) days in all?

…………………..days

**15.** If household contributed nothing, then who paid for the toilet?
(1) NGO
(2) District Council/Government
(3) A Councilor
(4) Philanthropist
(5) Community elders/leaders
(6) Other (please specify) ……………………………………………

**16.** Do you spend any money on cleaning or keeping the toilet facility clean?
(1) Yes, on detergents
(2) Yes, on disinfectants
(3) Yes, on both detergents and disinfectants
(4) No [if this, go >>>>> Q17]

**17.** How much do you spend on keeping the toilet clean then?

Le: ………………………….. per day/week/month

**18.** Has the household ever emptied /desludged the latrine?
(1) Yes (2) No (3) Don't know

**19.** If **Q17** is Yes, how much have you spent on desludging and for how many times?

Le ………………………., for (1) once (2) twice (3) thrice (4) four times (5) 5 & more

**20.** Has there ever been any repair works on the toilet facility?

(1) Yes (2) No (3) not sure [if No/not sure go >>>>> Q21]

**21.** If any repair works occurred, then how much have you spent over the years?
(1) Le ………………………., year ………………
(2) Le ………………………., year ………………
(3) Le ………………………., year ………………

**22.** How many of your households use this household latrine?
(1) all
(2) some
(3) few
(4) none

**23.** How many other households use your toilet facility?
……………… (1) estimate (2) actual

**24.** If toilet facility was constructed by landlady/another, does your household use it?
(1) Yes (2) No

**25.** If Yes, how often is your household allowed to use the toilet facility?
(1) all the time
(2) sometimes

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(3) occasionally
(4) erratic

**26.** Where do the majority of adults in your household defecate? (Tick one applicable)
(1) use the household latrine/toilet facility
(2) use toilet facility in the house
(3) use neighbour's latrine/toilet facility
(4) use the communal or public latrine /toilet facility
(5) use the school/institutional toilet/latrine
(6) practice dig & bury
(7) practice open defecation

**27.** Where do the majority of children (above 5 years, less than 16 years) of your household defecate? (tick only one applicable)
(1) use a potty
(2) use a disposal diapers
(3) use washable (reuseable) diapers
(4) use the household latrine
(5) use toilet facility in the house
(6) use neighbour's latrine
(7) use the communal or public latrine
(8) use the school/institutional latrine
(9) practice dig & bury
(10) practice open defecation

**28.** Where do the majority children of 5 yrs and below of your household defecate? (tick one applicable)
(1) use a potty
(2) use a disposal diapers
(3) use washable (reuseable) diapers
(4) use the household latrine
(5) use toilet facility in the house
(6) use neighbour's latrine
(7) use the communal or public latrine
(8) use the school/institutional latrine
(9) practice dig & bury
(10) practice open defecation

**29.** What type is the neighbor/communal/public/institutional latrine? (ask for description)
(1) Flush (WC/ Pour) to septic tank
(2) Flush to pit (latrine)
(3) Flush to somewhere else
(4) Ventilated Improved Pit latrine (VIP)
(5) Pit latrine with slab (impermeable slab, e.g. sanplat)
(6) Pit latrine without slab/open pit (e.g. traditional pit latrine)
(7) Composting toilet
(8) Bucket/pan latrine
(9) Hanging toilet/latrine is a toilet built over a water body (e.g. sea/river)
(10) Bush or field or open defecation or no facilities

**30.** Where are the faeces of the children who use potty disposed?
(1) In the latrine
(2) Wash it into drains
(3) Drop anywhere
(4) Send away with the garbage
(5) Bury near-by
(6) Send to the farm to bury
(7) Throw into the yard/street/gutter
(8) Don't know

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**Previous hygiene intervention**

**31.** Do you know of any sanitation & hygiene promotion organised/discussed in your community? (1) Yes (2) No (3) Don't Know

**32.** When was this discussion/programme?

(1) less than a year ago (2) between 1 & 3 years (3) more then 5 years ago (4) Don't Know

**33.** Who facilitated?
- (1) NGO person
- (2) Environmental Health Personnel
- (3) Someone else from the district council
- (4) Community leader(s)/elder(s)
- (5) Other ………………………………………..….
- (6) Don't know

**34.** Has any household member been involved in hygiene promotion activities in the last 12 months? (1) yes (2) No (3) don't know

**35.** If Yes, what type of activities did you or another household member participate in?

(1) Group/community meeting (2) individual meeting (3) drama (4) other

**36.** How much time in total did you or another household member spend on this activity in hours?
…………. hrs for (1) once (2) twice (3) thrice (4) 4 times (5) 5 & more

**Drinking water source and management**

**37.** What is your main source of drinking water? (tick only one)
- (1) Tap inside house
- (2) Tap in compound/yard tap
- (3) Public standpipe
- (4) Borehole/well with handpump
- (5) Protected spring
- (6) Unprotected well/open well/hand-dug well
- (7) Unprotected spring- river or dug out
- (8) Household harvested rainwater
- (9) Water tanker/bousers
- (10) Sachet or bottled water

**38.** What is the household main source of water for bathing/washing down?
- (1) Tap inside house
- (2) Tap in compound/yard tap
- (3) Public standpipe
- (4) Borehole/well with handpump
- (5) Protected spring
- (6) Unprotected well/open well/hand-dug well
- (7) Unprotected spring- river or dug out
- (8) Household harvested rainwater
- (9) Water tanker/bousers
- (10) Sachet or bottled water

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**39.** In 12 months, has the household been compelled to use any unsafe water for drinking/ cooking?
(1) Never, not all
(2) Once
(3) A couple of times
(4) Once per month
(5) Many times in a month
(6) Not sure, I don't remember

**40.** Does your household treat water in anyway?
(1) Yes, always
(2) Yes, sometimes
(3) No [if this go >>>>>> **Q42**]
(4) Don't know [if this go >>>>>> **Q42**]

**41.** If your household treats water, how do you do it?
(9) Chlorination
(10) Filtration with a ceramic device (such as a clay pot, or a candle filter)
(11) Filtration with a bio-sand filter
(12) Filtration with a filter cloth
(13) Solar disinfection
(14) Boiling
(15) Use chemical coagulant (such as aluminum salt or iron salt)
(16) Other (Specify) ……………………………………..

**42.** Your household treats the water for what purpose? [tick all those applicable]
(1) drinking
(2) cooking
(3) dish washing
(4) bathing/washing down (children)
(5) preparing baby/children's food
(6) for general purposes/uses

**43.** Does your household store your water? (1) Yes (2) No

**44.** The water is stored for what use/purpose?
(1) Drinking only
(2) Cooking only
(3) Drinking & cooking only
(4) Washing purposes only
(5) Preparing baby food
(6) For all purposes

**Handwashing**

**45.** When do adults in your household wash their hands? [Please don't prompt, tick if valid]
(1) Before eating
(2) After eating
(3) Before praying
(4) Before breastfeeding or feeding a child
(5) Before cooking or preparing food
(6) After defecation/urination
(7) After cleaning a child that has defecated/changing a child's nappy
(8) When my hands are dirty
(9) After cleaning the toilet or potty
(10) Other (please list) ……………………………
(11) Don't know

**46.** When do children of the household wash their hands? (Please don't prompt, tick if valid)
(1) Before eating
(2) After eating

(3) Before praying
(4) Before breastfeeding or feeding a child
(5) Before cooking or preparing food
(6) After defecation/urination
(7) After cleaning a child that has defecated/changing a child's nappy
(8) When my hands are dirty
(9) After cleaning the toilet or potty
(10) Other (please list) ……………………………
(11) Don't know

**47.** Describe how children wash their hands in this household? (don't prompt, tick if valid)
(1) adults help them by washing using water
(2) adults help them by washing using water & soap/soap substitute
(3) the children wash themselves under supervision
(4) the children wash themselves as supposed

**48.** Do you have a designated handwashing equipment/station/facility in the compound?
(1) Yes (2) No

**49.** Kindly describe this facility /equipment
(1) I don't know
(2) Cup/dipper with a bucket
(3) Container with tap (e.g. veronica bucket)
(4) Pour directly from container (e.g. jerry can)
(5) Modern sink
(6) Other …………………………………………..

**50.** Where is the handwashing facility /equipment located?
(1) in the kitchen
(2) bathroom
(3) toilet facility
(4) in the compound /yard
(5) on the corridor
(6) place of eating
(7) other (please specify)……………………………………………….

**51.** When does the household mostly use it?
(1) Eating/feeding time
(2) defecation time
(3) after farm
(4) cooking/food serving time
(5) after outings
(6) after kids play
(7) prayer time
(8) other …………………………………………………

**52.** What was the cost for the handwashing facility/equipment?

Le:…………………year: ………………………………………..

**53.** How much did you spend on soap last month?

Le: ……………………….

**Observations**

**54.** OBS: May I see where you store your drinking water? (1) Yes
(2) No

**55.** OBS: Storage container for drinking water has (tick all those applicable)
(1) Wide mouth (about > 10cm across)
(2) Narrow mouth (< 10cm across)
(3) A tap/spigot
(4) A dipper/cup/item for withdrawing water
(5) No dipper/cup/item for withdrawing water
(6) A lid/ fitted cover on it
(7) No lid/ fitted cover on it

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**56.** OBS: Can I see the handwashing facility at the kitchen?
(1) Yes, available
(2) No, nothing exist
(3) No, not allowed

**57.** OBS: Handwashing facility at or around the kitchen area?
(1) Has water in a storage vessel
(2) Has water in a storage vessel with a dipper/cup for withdrawal
(3) Has a tap with running water
(4) Has no water available
(5) Has a soap or soap substitute available
(6) Has no soap or soap substituted in place

**58.** OBS: Inspect the type of toilet facility (ask for permission to see toilet)
(1) Flush (WC/ Pour) to septic tank
**(2)** Flush to pit (latrine)
**(3)** Flush to somewhere else
**(4)** Ventilated Improved Pit latrine (VIP)
**(5)** Pit latrine with slab (impermeable slab, e.g. sanplat)
**(6)** Pit latrine without slab/open pit (e.g. traditional pit latrine)
**(7)** Composting toilet
**(8)** Bucket/pan latrine
**(9)** Hanging toilet/latrine is a toilet built over a water body (e.g. sea/river)
**(10)** Bush or field or open defecation or no facilities

**59.** OBS: Has the toilet any handwashing facility?
(1) Yes, handwashing facility is found attached
(2) Yes, handwashing facility is installed close-by (within 10 meters)
(3) No handwashing facility can be spotted anywhere

**60.** OBS: Handwashing facility at or around the latrine/toilet area?
(1) Has water in a storage vessel
(2) Has water in a storage vessel with a dipper/cup for withdrawal
(3) Has a tap with running water
(4) Has no water available
(5) Has a soap or soap substitute available
(6) Has no soap or soap substituted in place

**61.** OBS: Cleanliness of the toilet facility (tick all those applicable)
(1) The walls are free from faeces
(2) The floors are free from faeces
(3) used anal cleansing materials are scattered on the floor
(4) used cleansing materials are well kept in container with a fitted cover
(5) squatting holes/bowls/seats are kept clean
(6) squatting holes/bowls/seats are smeared and dirty

**62.** OBS: flies and odour (tick all those applicable)
(1) latrine is filled with a strong odour
(2) latrine has a mild odour
(3) latrine has no odour
(4) latrine is invaded by flies
(5) few flies (less than 10) are hardly spotted
(6) no flies can be spotted inside the latrine

### Table 7-7: Water point data

| Facility Type* | Code (eg HDW 1 etc…) | Type of handpump (if applicable) | Construction cost (leones) | Year of construction | Functional (Yes, No) | Number of regular users (estimated) | | Number of days **not** functioning (last 12 months) | Repairs/ work undertaken | | | Financing organisation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Dry Season | Wet Season | | Activity | Year | Cost (leone) | |
| Example 1: Borewell with handpump | BW 1 | India Mark II | 25 million | 2008 | Yes | 175 | | 330 | Repair to cylinder | 2009 | 600,000 | Community |
| | | | | | | | | | Repair to Handpump | 2011 | 100,000 | Community |
| Example 2: Hand-dug well | HDW 1 | Kardia | 17 million | 2010 | Yes | 200 | | 365 | None | | | N/A |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

* Hand-dug well (HDW); Borehole and hand pump (BH+HP); Other…

**Table 7-8: Enumerator Overview of Water point location**

| Community Name: | | |
|---|---|---|
| Type of Water point | Code | Description of location (this can be used to crosscheck with households the actual water point that the household is accessing) |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

This is a short input table that should be completed by each enumerator during water point mapping. This is to ensure that in the larger communities visited enumerators can keep track of the location and code associated with each water point

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**Table 7-9: District Council data survey (W–DCS)**

| | | |
|---|---|---|
| Date of survey: | Community: | |
| District council: | Province: | |
| Enumerator: | | |
| **District Council details** | | |
| District Council population: | | |
| **District water facility summary** | | |
| Facility Type | Total Number | Number functional |
| Piped water systems (small towns) | | |
| Spring box/protected springs | | |
| Rural gravity fed systems | | |
| Hand-dug well with handpump | | |
| Borehole with hand pump | | |
| Standpost | | |
| Other… | | |
| Source of this data: | | |
| **District Activities + Cost** | | |
| Is there a district water department? | When was it established? | |
| How many people are employed within the department? | | |
| What are the responsibilities of the district water department (description)? (prompt ideas on – support to communities, monitoring, financial support) | | |
| Is the department sufficiently resourced to perform its functions (in terms of transport, travel, allowances, logistical facilities, computers etc..) ? (Yes / No)<br><br>If No what shortcomings: | | |

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| |
|---|
| What are the consequences of these shortcomings? |
| Over the course of last year has the water department monitored community water facilities in terms of financial and technical performance? (Yes, Ad hoc, No) |
| What was the budget **spent** on water operational activities (transport, fuel etc) for last year? (Leone's) |
| What was the budget **spent** on district water department wages in the last year? (Leone's) |
| What was the budget **spent** on water capital investment last year? (Leone's) |
| **Expenditure on maintenance** |
| Has the district council ever funded major repair, rehabilitation or construction of facilities in the last three years? (Yes, No)<br><br>If yes: please fill details in District Council CapEx/CapManEx worksheet. |

## C.3 Data collection in rural Ghana

**Table 7-10: Key informant interviews of undertaken in rural Ghana**

<table>
<tr><th>Date</th><th>Interviewee</th><th>Organisation</th><th>Position</th></tr>
<tr><td>24-01-13</td><td>Mr Gaze</td><td rowspan="4">CWSA Head Office</td><td>Director Technical Services</td></tr>
<tr><td>24-01-13</td><td>Mr Kubabom</td><td>Director Planning and Investment</td></tr>
<tr><td>25-01-13</td><td>Mrs Abbey</td><td>IT co-ordinator</td></tr>
<tr><td>25-01-13</td><td>Ms Engman</td><td>WASH Coordinator</td></tr>
<tr><td>29-01-13</td><td>Naa Dogoli</td><td rowspan="4">CWSA Regional Office - Volta</td><td>Regional Director of CWSA</td></tr>
<tr><td>28-01-13</td><td>Mr Johnson</td><td>CWSA Regional Engineer</td></tr>
<tr><td>28-01-13</td><td>Mr Sylvester Eyramh</td><td>Extension service specialist with the MoM unit</td></tr>
<tr><td>29-01-13</td><td>Mr. Oscar Philip Ahianyo</td><td>Extension service specialist</td></tr>
<tr><td>7/2/2013</td><td>Mr John Aduakye</td><td rowspan="4">CWSA Regional Office – Northern</td><td>Hydro-geologist – CWSA Northern region</td></tr>
<tr><td>8/2/2013</td><td>Mr Moses Bagbile</td><td>Extension service specialist</td></tr>
<tr><td>8/2/2013</td><td>Mr Steve Anonlan</td><td>Extension service specialist</td></tr>
<tr><td>7/2/2013</td><td>Ms Patricia Gyamfi</td><td>IT specialist</td></tr>
<tr><td>4/2/2013</td><td>Mr Seth Damasah</td><td rowspan="3">Akatsi South District Assembly</td><td>District WASH Engineer</td></tr>
<tr><td>31-01-13</td><td>Mr. Jacob Nunekpeku</td><td>Planning officer</td></tr>
<tr><td>30-01-13</td><td>Mr. Sammy Davor</td><td>Environmental health officer</td></tr>
</table>

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| | | | |
|---|---|---|---|
| 11/2/2013 | Mr. Bashiru Shaibu | | Environmental health officer |
| 11/2/2013 | Mr. Osuman Memuna | | Community officer |
| 11/2/2013 | Mr. Yakubu Braimah | | Engineer DWD |
| 11/2/2013 | Alhaji Abdul Karim Y. Iddrisu | East Gonja District Assembly | District coordinating director |
| 12/2/2013 | Mr. Khalid Abubakari | | Planning officer |
| 12/2/2013 | Alhaji Mahama Zakaria | | Finance officer |

**Table 7-11: Focus groups and multi-stakeholder interviews**

| Date | Description | Location | Community name |
|---|---|---|---|
| 2/2/2013 | | | Ave Afiadenyigba (New town) |
| 4/2/2013 | | | Agbagblakope |
| 4/2/2013 | | Akatsi district | Agbedrafor |
| 4/2/2013 | WSMT for small communities focus groups | | Agornu Kporkblortey |
| 4/2/2013 | | | Adzikame Agbalekope |
| 4/2/2013 | | | Adzikame Gavorkope |
| 11/2/2013 | | East Gonja | N/A (Environs of Salaga Town) |
| 31-01-13 | Area mechanics of focus group | | N/A |
| 31-01-13 | Environmental health assistant focus group | | N/A |
| 31-01-13 | WSMTs for small towns group interview | Akatsi district | Akatsi |
| 2/2/2013 | WSMTs for small towns interview + site visit | | Ave Dakpa |
| 11/2/2013 | WSMTs for small towns interview + site visit | East Gonja district | Salaga |
| 11/2/2013 | Area mechanics focus groups | | N/A |

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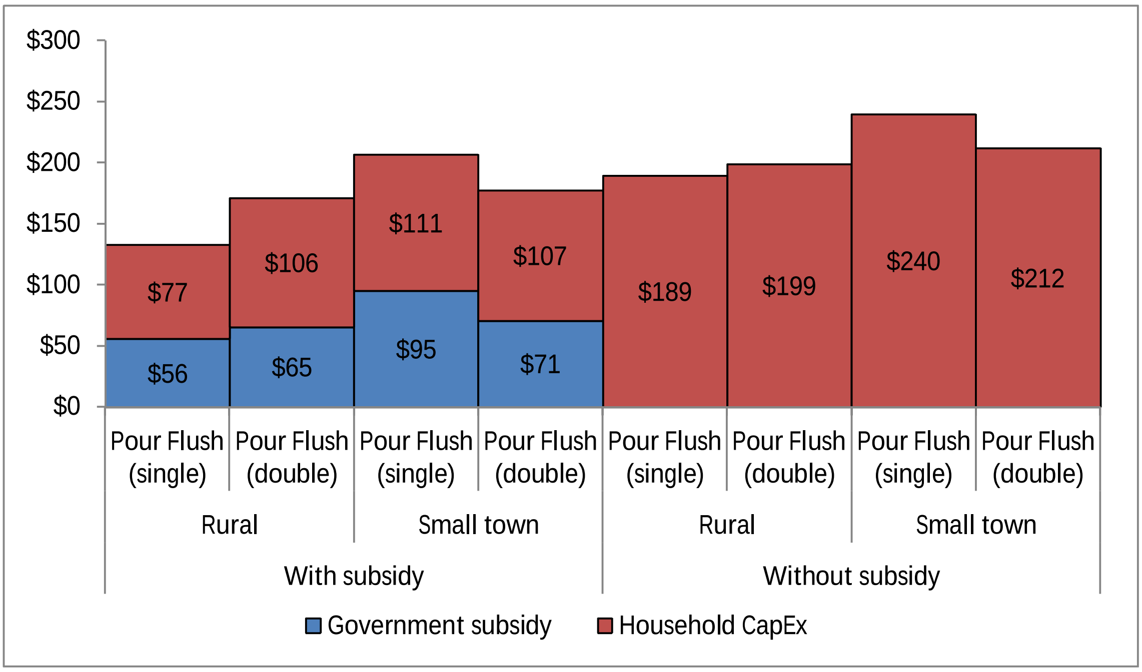
# Appendix D Supporting information sanitation chapter

## D.1 Subsidies of latrines in Andhra Pradesh state

**Figure 7-6: Comparison of median of capital expenditure on latrines with and without subsidy in Andhra Pradesh, India**




## D.2 Statistics for sanitation chapter

*India – Kruskal Wallis Test – Capital Expenditure*

**Table 7-12: Overview of Kruskal-Wallis data India CapEx**

| | |
|---|---|
| number of samples | 4 |
| degrees of freedom | 3 |
| alpha | 0.05 |
| H critical (alpha 0.05) | 7.814727903 |
| test statistic H | 63.89009925 |
| tot number of tied values | 256 |
| test statistic H corrected for ties | 63.89035857 |
| p value | 8.66338E-14 |

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**Decision:** The observed test statistic H (63.89) is significantly greater than the critical H (7.815), at alpha= 0.05. There is a significant difference between samples. The associated probability (p) is 0.

**Table 7-13: Bonferroni test data India CapEx**

| | |
|---|---|
| number of samples | 4 |
| number of pairwise comparisons | 6 |
| family alpha | 0.05 |
| Bonferroni individual alpha | 0.008 |
| Bonferroni Z-value (2-sided) | 2.638 |

**Table 7-14: Pairwise comparison on significance CapEx India (bonferroni adjusted alpha 0.008)**

| Technology | Single pit pour flush latrine (Rural) | Double pit pour flush latrine (Rural) | Single pit pour flush latrine (Town) |
|---|---|---|---|
| Single pit pour flush latrine (Rural) | - | | |
| Double pit pour flush latrine (Rural) | 0.017 | - | |
| Single pit pour flush latrine (Town) | 0.000 | 0.051 | - |
| Double pit pour flush latrine (Town) | 0.149 | 0.782 | 0.066 |

*Burkina Faso – Kruskal Wallis Test – Capital Expenditure*

**Table 7-15: Overview of Kruskal-Wallis data Burkina Faso CapEx**

| | |
|---|---|
| number of samples | 3 |
| degrees of freedom | 2 |
| alpha | 0.05 |
| H critical (alpha 0.05) | 5.991464547 |
| test statistic H | 184.090931 |
| tot number of tied values | 110 |
| test statistic H corrected for ties | 184.0974997 |
| p value | 1.05617E-40 |

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**Decision:** The observed test statistic H (184.091) is significantly greater than the critical H (5.991), at alpha= 0.05. There is a significant difference between samples. The associated probability (p) is 0.

**Table 7-16: Bonferroni test data Burkina Faso CapEx**

| | |
|---|---|
| number of samples | 3 |
| number of pairwise comparisons | 3 |
| family alpha | 0.05 |
| Bonferroni individual alpha | 0.017 |
| Bonferroni Z-value (2-sided) | 2.394 |

**Table 7-17:Pairwise comparison on significance CapEx Burkina Faso (bonferroni adjusted alpha 0.017)**

| Technology | Rural Slab | Town Slab | Town VIP |
|---|---|---|---|
| Rural Slab | - | | |
| Town Slab | 0.000 | - | |
| Town VIP | 0.000 | 0.000 | - |

*Ghana – Kruskal Wallis Test – Capital Expenditure*

**Table 7-18: Overview of Kruskal-Wallis data Ghana CapEx**

| | |
|---|---|
| number of samples | 3 |
| degrees of freedom | 2 |
| alpha | 0.05 |
| H critical (alpha 0.05) | 5.99 |
| test statistic H | 3.62 |
| tot number of tied values | 10 |
| test statistic H corrected for ties | 3.62 |
| p value | 0.16 |

**Decision:** The observed test statistic H (3.62) is not significantly greater than the critical H (5.991) at alpha= 0.05. There is not a significant difference between samples.

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*Mozambique – Kruskal Wallis Test – Capital Expenditure*

**Table 7-19: Overview of Kruskal-Wallis data Mozambique CapEx**

| | |
|---|---|
| number of samples | 5 |
| degrees of freedom | 4 |
| alpha | 0.05 |
| H critical (alpha 0.05) | 9.487729037 |
| test statistic H | 183.2495091 |
| tot number of tied values | 239 |
| test statistic H corrected for ties | 203.1089742 |
| p value | 8.06123E-43 |

The observed test statistic H (183.25) is significantly greater than the critical H (9.488), at alpha= 0.05. There is a significant difference between samples. The associated probability (p) is 0.

**Table 7-20: Bonferroni test data Mozambique CapEx**

| | |
|---|---|
| number of samples | 5 |
| number of pairwise comparisons | 10 |
| family alpha | 0.05 |
| Bonferroni individual alpha | 0.005 |
| Bonferroni Z-value (2-sided) | 2.807 |

**Table 7-21: Pairwise comparison on significance CapEx Mozambique (bonferroni adjusted alpha 0.005)**

| Technology | Rural TPL | Rural Slab | Town TPL | Town Slab |
|---|---|---|---|---|
| Rural TPL | - | | | |
| Rural Slab | 0.000 | - | | |
| Town TPL | 0.212 | 0.002 | - | |
| Town Slab | 0.000 | 0.006 | 0.000 | - |
| Town VIP | 0.000 | 0.001 | 0.000 | 0.062 |

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*Sierra Leone – Kruskal Wallis Test – Capital Expenditure*

**Table 7-22: Overview of Kruskal-Wallis data Sierra Leone CapEx**

| | |
|---|---|
| number of samples | 3 |
| degrees of freedom | 2 |
| alpha | 0.05 |
| H critical (alpha 0.05) | 5.99146 |
| test statistic H | 16.6098 |
| tot number of tied values | 158 |
| test statistic H corrected for ties | 16.6165 |
| p value | 0.00024 |

**Decision:** The observed test statistic H (16.61) is significantly greater than the critical H (5.991), at alpha= 0.05. There is a significant difference between samples. The associated probability (p) is 0.0002.

**Table 7-23: Bonferroni test data Sierra Leone CapEx**

| | |
|---|---|
| number of samples | 3 |
| number of pairwise comparisons | 3 |
| family alpha | 0.05 |
| Bonferroni individual alpha | 0.017 |
| Bonferroni Z-value (2-sided) | 2.394 |

**Table 7-24: Pairwise comparison on significance CapEx Sierra Leone (bonferroni adjusted alpha 0.017)**

| Technology | Rural TPL | Rural IPL | Rural VIP |
|---|---|---|---|
| Rural TPL | - | | |
| Rural IPL | 0.000 | - | |
| Rural VIP | 0.766 | 0.214 | - |

*Cross country analysis – Kruskal Wallis Test – Capital Expenditure*

**Table 7-25: Overview of Kruskal-Wallis data all country CapEx**

| | |
|---|---|
| number of samples | 5 |
| degrees of freedom | 4 |
| alpha | 0.05 |
| H critical (alpha 0.05) | 9.487729037 |
| test statistic H | 2230.044884 |
| tot number of tied values | 304 |
| test statistic H corrected for ties | 2231.426506 |
| p value | 0 |

**Decision:** The observed test statistic H (2230.045) is significantly greater than the critical H (9.488), at alpha= 0.05. There is a significant difference between samples. The associated probability (p) is 0.

**Table 7-26: Bonferroni test data all country CapEx**

| | |
|---|---|
| number of samples | 5 |
| number of pairwise comparisons | 10 |
| family alpha | 0.05 |
| Bonferroni individual alpha | 0.005 |
| Bonferroni Z-value (2-sided) | 2.807 |

**Table 7-27: Pairwise comparison on significance CapEx all countries (bonferroni adjusted alpha 0.005)**

| Country | India | Burkina Faso | Ghana | Mozambique |
|---|---|---|---|---|
| India | - | | | |
| Burkina Faso | 0.000 | - | | |
| Ghana | 0.002 | 0.536 | - | |
| Mozambique | 0.000 | 0.000 | 0.000 | - |
| Sierra Leone | 0 | 0 | 2.06398E-05 | 7.30918E-11 |

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*Burkina Faso– Kruskal Wallis Test – Recurrent Expenditure*

**Table 7-28: Overview of Kruskal-Wallis data Burkina Faso recurrent expenditure**

| | |
|---|---|
| number of samples | 3 |
| degrees of freedom | 2 |
| alpha | 0.05 |
| H critical (alpha 0.05) | 6 |
| test statistic H | 107 |
| tot number of tied values | 112 |
| test statistic H corrected for ties | 107 |
| p value | 6.28732E-24 |

**Decision:** The observed test statistic H (106.692) is significantly greater than the critical H (5.991), at alpha= 0.05. There is a significant difference between samples. The associated probability (p) is 0.

**Table 7-29: Bonferroni test data Burkina Faso recurrent expenditure**

| | |
|---|---|
| number of samples | 3 |
| number of pairwise comparisons | 3 |
| family alpha | 0.05 |
| Bonferroni individual alpha | 0.017 |
| Bonferroni Z-value (2-sided) | 2.394 |

**Table 7-30: Pairwise comparison on significance recurrent expenditure Burkina Faso (bonferroni adjusted alpha 0.017)**

| Technology | Improved pit latrine (Rural) | Improved pit latrine (Town) | VIP (Town) |
|---|---|---|---|
| Improved pit latrine (Rural) | - | | |
| Improved pit latrine (Town) | 0.000 | - | |
| VIP (Town) | 0.000 | 0.168 | - |

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*Mozambqiue– Kruskal Wallis Test – Recurrent Expenditure*

**Table 7-31: Overview of Kruskal-Wallis data Mozambique recurrent expenditure**

| | |
|---|---|
| number of samples | 5 |
| degrees of freedom | 4 |
| alpha | 0.05 |
| H critical (alpha 0.05) | 9 |
| test statistic H | 450 |
| tot number of tied values | 333 |
| test statistic H corrected for ties | 485 |
| p value | 9.7962E-104 |

**Decision:** The observed test statistic H (449.542) is significantly greater than the critical H (9.488), at alpha= 0.05. There is a significant difference between samples. The associated probability (p) is 0.

**Table 7-32: Bonferroni test data recurrent expenditure Mozambique**

| | |
|---|---|
| number of samples | 5 |
| number of pairwise comparisons | 10 |
| family alpha | 0.05 |
| Bonferroni individual alpha | 0.005 |
| Bonferroni Z-value (2-sided) | 2.807 |

**Table 7-33: Pairwise comparison on significance recurrent expenditure Mozambique (bonferroni adjusted alpha 0.005)**

| | Traditional Pit Latrine (rural) | Improved pit latrine (Rural) | Traditional Pit Latrine (Town) | Improved pit latrine (Town) | VIP (Town) |
|---|---|---|---|---|---|
| Traditional Pit Latrine (rural) | - | | | | |
| Improved pit latrine (Rural) | 0.582 | - | | | |
| Traditional Pit Latrine (Town) | 0.000 | 0.000 | - | | |
| Improved pit latrine (Town) | 0.000 | 0.000 | 0.000 | - | |
| VIP (Town) | 6E-07 | 7E-06 | 9E-02 | 0.780 | - |

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*Sierra Leone– Kruskal Wallis Test – Recurrent Expenditure*

**Table 7-34: Overview of Kruskal-Wallis data Sierra Leone recurrent expenditure**

| | |
|---|---|
| number of samples | 3 |
| degrees of freedom | 2 |
| alpha | 0.05 |
| H critical (alpha 0.05) | 5.991464547 |
| test statistic H | 18.5092621 |
| tot number of tied values | 126 |
| test statistic H corrected for ties | 18.72532967 |
| p value | 8.5871E-05 |

**Decision:** The observed test statistic H (18.509) is significantly greater than the critical H (5.991), at alpha= 0.05. There is a significant difference between samples. The associated probability (p) is 0.0001.

**Table 7-35: Bonferroni test data recurrent expenditure Sierra Leone**

| | |
|---|---|
| number of samples | 3 |
| number of pairwise comparisons | 3 |
| family alpha | 0.05 |
| Bonferroni individual alpha | 0.017 |
| Bonferroni Z-value (2-sided) | 2.394 |

**Table 7-36: Pairwise comparison on significance recurrent Sierra Leone (bonferroni adjusted alpha 0.017)**

| Technology | TPL | IPL | VIP |
|---|---|---|---|
| TPL | - | | |
| IPL | 0.000 | - | |
| VIP | 0.967 | 0.128 | - |

*Cross country comparison – Kruskal Wallis Test – Recurrent Expenditure*

**Table 7-37: Overview of Kruskal-Wallis data all country recurrent expenditure**

| | |
|---|---|
| number of samples | 5 |
| degrees of freedom | 4 |
| alpha | 0.05 |

| | |
|---|---|
| H critical (alpha 0.05) | 9 |
| test statistic H | 941 |
| tot number of tied values | 344 |
| test statistic H corrected for ties | 942 |
| p value | 1.1677E-202 |

**Decision:** The observed test statistic H (941.43) is significantly greater than the critical H (9.488), at alpha= 0.05. There is a significant difference between samples. The associated probability (p) is 0.

**Table 7-38: Bonferroni test data recurrent expenditure all countries**

| | |
|---|---|
| number of samples | 5 |
| number of pairwise comparisons | 10 |
| family alpha | 0.05 |
| Bonferroni individual alpha | 0.005 |
| Bonferroni Z-value (2-sided) | 2.807 |

**Table 7-39: Pairwise comparison on significance recurrent expenditure all countries (bonferroni adjusted alpha 0.005)**

| | India | Burkina Faso | Ghana | Mozambique |
|---|---|---|---|---|
| India | - | | | |
| Burkina Faso | 0.000 | - | | |
| Ghana | 0.000 | 0.009 | - | |
| Mozambique | 0.000 | 0.000 | 0.000 | - |
| Sierra Leone | 8E-12 | 0E+00 | 2E-12 | 0.000 |

## D.3 Direct and indirect support expenditure

Expenditure on direct support was calculated in Andhra Pradesh from bulk state level expenditure on staff salaries and information, education and communication activities. This has been combined with indirect support costs estimated using the national and state level budget allocations on activities including planning, research and policy development. Together these represent an expenditure of $0.20 per person, per year in rural areas and a negligible amount in small town areas. This information was only available at state level and no additional information was available about how this expenditure was proportioned amongst the districts where data collection took place.

In Mozambique, direct and indirect support expenditure by the national DEC (sanitation department) was negligible when proportioned across rural and small town populations. District level expenditure broadly targeted at rural sanitation projects was collected in the relevant study areas. This expenditure amounted to a median value of $0.30 per person per year in rural areas equating to $0.20 per person per year across the whole sample.

No direct support values were available in Burkina Faso, Ghana or Sierra Leone that could be attributed to sanitation.

## D.4 Explanation of Mozambique slab cost

In 2011, the cost of purchasing an unreinforced domed concrete slab was found to be 500 Mozambique Metical across a selection by vendors in Maputo – this represents an equivalent 2012 current cost of $18 (see figure X). This cost is likely to vary between regions and rural and small town areas.

**Figure 7-7: An unreinforced domed concrete slab for sale in Maputo**

Photo credit: Franceys (2011)

**Table 7-40: Number (and percentage) of households incurring a financial cost in Mozambique**

| Latrine type | Rural latrines | Town latrines | All latrines |
|---|---|---|---|
| TPL | 102 (21%) | 54 (26%) | 156 (22%) |
| IPL | 18 (51%) | 97 (75%) | 115 (70%) |
| VIP | No data | 12 (100%) | 12 (100%) |

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# Appendix E Supporting data water chapter

## E.1 Summary of water service delivery in the five countries

*Andhra Pradesh*

Water services in Andhra Pradesh reflect a legacy of repeated efforts to improve water supplies in rural India through enhancement and renewal, which has resulted in a complex pattern of boreholes with handpumps in every community where WASHCost research took place, often alongside piped networks supplying water to standpipes and household connections. These services are usually funded and constructed by governmental agencies. They are often augmented by private household water sources, as those with more resources in villages/towns seek to secure their own supplies. Many residents access water from multiple informal and formal water sources at different times of the day and for different purposes, making it challenging to disaggregate expenditure and service levels for and by a particular source.

Government expenditure on WASH infrastructure was collected from 187 villages across nine agro-climatic zones. In addition, valid information about household expenditure and the service levels accessed by residents was collected in 5,242 household surveys covering 103 of these villages.

Of rural Andhra Pradesh villages sampled, 12% were supplied through traditional boreholes and handpumps alone; 45% through single-village or multi-village piped networks; and 43% through a mix of piped networks.

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**Table 7-41: Service delivery models found in Andhra Pradesh**

| Service delivery model | Service area size | Nº of service areas with expenditure data | Average service area size | Nº of service areas with service level data | Average community size |
|---|---|---|---|---|---|
| Borehole and handpump | | 22 | 482 | 12 | 475 |
| Mechanised borehole | Small | 17 | 262 | 4 | 247 |
| | Medium | 17 | 1,128 | 8 | 1,509 |
| Single-village/town network | Small | 2 | 441 | NA | NA |
| | Medium | 28 | 1,559 | 14 | 1,389 |
| | Intermediate | 3 | 9,771 | NA | NA |
| Multi-village/town network | Small | 6 | 308 | 5 | 291 |
| | Medium | 11 | 1,591 | 8 | 1,697 |
| | Intermediate | 1 | 5,234 | 1 | 5,234 |
| Mixed piped supply | Small | 8 | 351 | 1 | 422 |
| | Medium | 66 | 1,510 | 47 | 1,414 |
| | Intermediate | 6 | 6,929 | 3 | 6,875 |

## ***Burkina Faso***

There are two key service delivery models for rural water supply in Burkina Faso: boreholes fitted with handpumps and small piped mechanised borehole systems. Burkina Faso national norms state that each borehole with handpump should serve 300 people with 20 litres of water per day at a distance on no more than one kilometre (km) from the point source. Each public tap stand should serve 500 people with 20 litres of water per day at a distance of no more than one km.

In Burkina Faso, data was collected in nine rural and small town service areas spanning three regions: Centre, Haute-Bassins and Nord. More than 2,500 household surveys were conducted across all nine service areas allowing for a comparison of expenditure and service levels (Table 7-42). The sample size and distribution were designed to illustrate the Burkina Faso context, but do not represent a statistically significant sample of the regional or national reality (Pezon and Bassono, 2012).

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Table 7-42: Study sample from Burkina Faso

| **Region** | **Nº of service areas visited** | **Nº schemes sampled** | | **Nº of household surveys** |
|---|---|---|---|---|
| | | Borehole and handpumps | Mechanised borehole systems | |
| Centre | 3 | 14 | 1 | 487 |
| Hauts-Bassins | 3 | 12 | 1 | 1,579 |
| Nord | 3 | 12 | 0 | 980 |

***Ghana***

Water service delivery in rural areas and small towns of Ghana are managed in different ways. Rural communities are typically supplied through boreholes with handpumps that are managed day to day by local Water and Sanitation Committees (WATSANs). The most common water service delivery models used to supply small towns are groundwater supplied piped networks, with provision for storage and household connections. There are two models of small town supply: single-town services, where the source, pumping and distribution are located within the service area; and multi-town services, where the source and pumping station are located close to a centralised source that supplies many communities. The development of piped town networks has happened relatively recently in Ghana, with the majority of systems constructed in the last decade. Small-town piped networks are typically managed by elected Water and Sanitation Development Boards (WSDBs) that take responsibility for operation and maintenance.

Overall responsibility for the ongoing provision of services in both rural and small town areas lies with district authorities, who in turn receive support from the Community Water and Sanitation Agency (CWSA) in the form of standards, guidelines for operations and maintenance, and in preparing strategic investment plans.

In Ghana, the sampling strategy focused on in-depth studies of rural point sources and small town community systems in three regions, encompassing three different hydro-geological zones. In total, 31 rural communities and four small towns were visited, and 1,273 household surveys were conducted (Table

7-43). Capital expenditure data was also gathered from the CWSA, specifically contract data on 1,591 boreholes with handpumps and financial records from a further 63 small town systems[45]. In each of the small towns, the number of users of formal sources was established, but not the number of people accessing informal sources. Therefore, for small town systems in this study all residents in the service area are assumed to use the formal piped service.

Table 7-43: Study sample in Ghana

| Region | District | Nº service areas visited | | Nº of HH surveys | |
|---|---|---|---|---|---|
| | | Rural villages | Small towns | Rural villages | Small towns |
| Ashanti | Bosomtwe | 10 | 1 | 488 | 132 |
| Northern | East Gonja | 15 | 2 | 153 | 30 |
| Volta | Ketu South | 6 | 1 | 391 | 79 |
| Other data sources | Contract data on 122 construction contracts for boreholes with handpumps and financial records from a further 63 small town systems. | | | | |

***Mozambique***

In rural areas of Mozambique, water services are provided through boreholes and handpump. Other supply options include open wells, protected spring sources as well as piped water networks in villages or small towns. Overall responsibility for water resource management lies with the Ministry of Public Works and Housing, and responsibility for policy development lies with the National Directorate of Water (DNA). In rural communities, water committees are responsible for the day to day operation and maintenance of water supply infrastructure. If the communities are unable to carry out the repairs themselves, they should seek to engage local pump mechanics or operators, and have a duty to inform district operators. The costs of repair and replacement are designed to be borne by the communities through tariffs.

[45] Additional data was sought as it became evident that it would be difficult to collect by other means. As these water points and small towns were not part of the original sampling areas, service level data is not available for the areas covered by these systems.


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Data on water points and households was collected in six out of the ten regions of Mozambique. The sampling methodology follows an approach developed by the National Bureau of Statistics (INE) of Mozambique as part of their multiple cluster survey of 2008, designed to deliver a representative sample of areas with access to formal water sources.

In addition, through close collaboration with DNA, more than 300 governmental contracts on the construction and rehabilitation of boreholes with handpumps were sourced from the National Information System for Water and Sanitation (SINAS) database. Specific enquiries outside the six main study regions provided additional expenditure data for single-village/town networks. A summary of the data sample for this study is shown in Table 7-44.

**Table 7-44: Study sample in Mozambique**

| **Region** | **Nº of water points visited (with valid expenditure data)** | | **Nº of household surveys** |
|---|---|---|---|
| | Boreholes with handpumps | Single-village/town networks | |
| Cabo Delgado | 17 (4) | 4 (3) | 230 |
| Inhambane | 22 (10) | 4 (1) | 180 |
| Manica | 15 (9) | | 210 |
| Maputo | 1 (1) | 4 (3) | |
| Nampula | 25 (19) | 5 (4) | 192 |
| Tete | 11 (9) | 2 (2) | 198 |
| Other data sources | 352 contracts from across the country for boreholes with handpumps (154 relating to capital expenditure hardware, 82 for capital maintenance, and 116 for capital expenditure software). | | |
| | Expenditure data from three single-village/town networks collected outside the primary study area in the Gaza and Sofala regions. | | |

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# Appendix F Supporting data Ghana chapter

## F.1 Supporting cost data

### Table 7-45: Bill of quantities for a 60 meter borehole

| Activity | Unit | Quantity | Unit Cost | Total Cost/GHC | Total Cost/US $ |
|---|---|---|---|---|---|
| Mobilisation and demobilization | | | | | |
| Mobilisation per borehole | l/s | 1 | 140 | 140 | $69 |
| De-mobilisation per borehole | l/s | 1 | 140 | 140 | $69 |
| Mounting and dismounting | BH | 1 | 300 | 300 | $147 |
| Movement | | | | | |
| Movement between worksites (8 out of 10 districts)+A34 | km | 30 | 50 | 1,500 | $735 |
| Movement between worksites (Northern region and Brong Affo region only) | km | 20 | 100 | 2,000 | $980 |
| Borehole drilling for diameter 125 mm (includes application of appropriate tech. Air drilling, mud drilling, reverse circulation drilling etc...) | | | | | |
| Drilling through overburden and highly weathered rock | m | 20 | 42 | 840 | $412 |
| Drilling through partially weathered to fresh crystalline consolidated, unconsolidated type of rock | m | 40 | 55 | 2,200 | $1,078 |
| Borehole construction (installation of screen, pvc pipes and screens. | | | | | |
| Supply and install pvc plain pipes and centralisers with a finished diameter of 125mm | m | 45 | 30 | 1,350 | $662 |
| Supply and install pvc slotted pipes (screens) and centralisers with a finished diameter of 125mm | m | 16 | 40 | 640 | $314 |
| Supply gravel pack (2-4mm) | m | 25 | 10 | 250 | $123 |
| Supply cement mix and grout seal above gravel | m | 1 | 20 | 20 | $10 |
| Backfill space above grout | m | 29 | 10 | 290 | $142 |
| Supply cement mix above grout | m | 4 | 20 | 80 | $39 |
| Borehole development (including egg. airlifting, mechanical surging, jetting, backwash over pumping) | hrs | 3 | 100 | 300 | $147 |
| Pumping test (constant rate of discharge and pumping test) | | | | | |
| Supply, install and remove pump test equipment | l/s | 1 | 300 | 300 | $147 |
| Conduct minimum six hours pumping test | hrs | 6 | 45 | 270 | $132 |
| Conduct 90% recovery test on HPs | hrs | 3 | 35 | 105 | $51 |
| Water quality test | | | | | |
| Take and store a WQ sample | l/s | 1 | 40 | 40 | $20 |
| Physical/chemical analysis | l/s | 1 | 250 | 250 | $123 |
| bacteriological analysis | l/s | 1 | 350 | 350 | $172 |
| Marginal and unsuccessful BHs (marginal = less than 10m per minute) | l/s | 1 | 105 | 105 | $51 |
| Borehole capping and/Bail plug | l/s | 1 | 30 | 30 | $15 |

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| | | | | | |
|---|---|---|---|---|---|
| Borehole concrete pad | l/s | 1 | 1,000 | 1,000 | $490 |
| Total (8 out of 10 districts) | | | | 10,500 | $5,145 |
| Total (Northern region and Brong Affo region only) | | | | 11,000 | $5,390 |

**Table 7-46: Expenditure on a single round of district data collection**

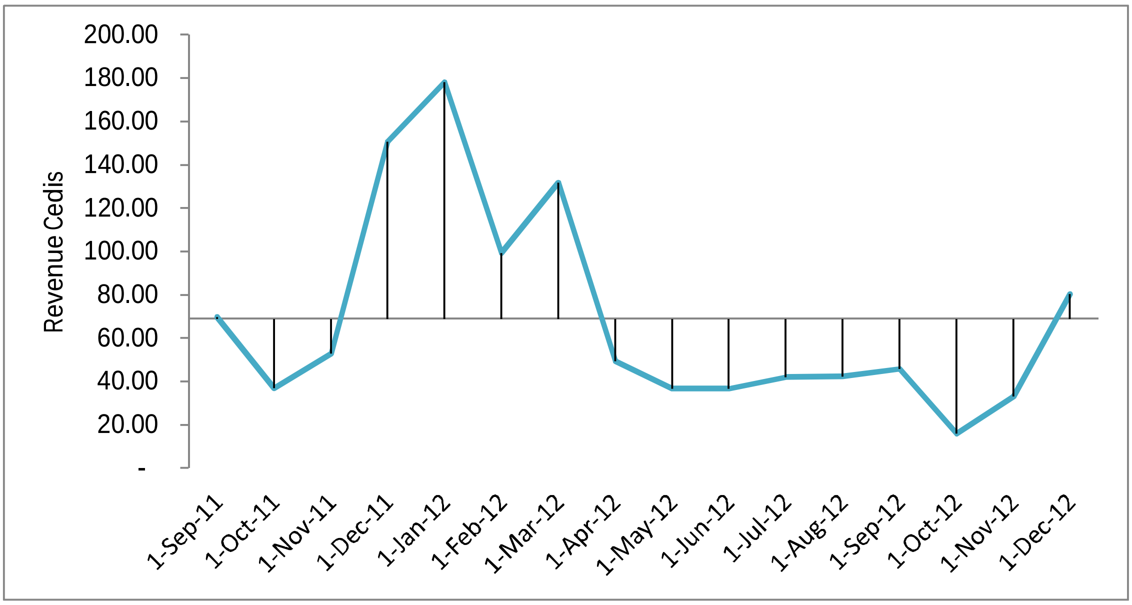
| Activity | Inputs/Item Description | No. of Days | Quantity | Unit Cost | Total Cost |
|---|---|---|---|---|---|
| To collect the data | Enumerators allowance | 25 | 6 | $25 | $3,807 |
| | Internet connection | 1 | 6 | $51 | $305 |
| | Enumerator transport and travel (Additional - not covered in the Triple - S budget) | 25 | 6 | $8 | $1,142 |
| | Sub-Total | | | | $5,254 |
| To validate the data | Food | 3 | 10 | $8 | $228 |
| | T&T | 3 | 8 | $5 | $122 |
| | RLF | 3 | 1 | $61 | $183 |
| | Driver | 3 | 1 | $41 | $122 |
| | RWST | 3 | 1 | $33 | $99 |
| | Sub-Total | | | | $754 |
| To share the data | Feeding | 1 | 30 | $8 | $228 |
| | Rapporteur allowance | 1 | 1 | $36 | $36 |
| | T & T | 1 | 30 | $5 | $152 |
| | RLF | 1 | 1 | $61 | $61 |
| | Driver | 1 | 1 | $41 | $41 |
| | Sub-Total | | | | $518 |
| Annual total | | | | | $6,525 |
| Annual total per person | | | | | $0.05 |

## F.2 Seasonal demand in Ave Afiadenyigba

Ave Afiadenyigba has four borehole and handpump systems and a population of approximately 1,678 (representing an average of 420 people per borehole). The WSMT keep very detailed records of operational and maintenance income and expenditure and share this information with the community every year. Figure 7-8 shows 16 months of income from the 4 boreholes. Over this period one of the boreholes had been padlocked for a 5 month period during the dryer months and another had been broken down for two months awaiting repair. The average monthly income from 4 boreholes was 69 GHC (equating to 207GHC per borehole, per year and just 0.6 GHC per borehole/per day). The revenue collected is very seasonal peaking in the dry season between December and March (Average monthly revenue = 117 GHC). In the wetter months between May and October, revenue drop by near 4 times to a monthly average of 31 GHC.

The total maintenance expenditure over the period was less that the revenue received at 704 GHC (176 GHC per borehole, equating to 132 GHC per borehole per year) – this included three occasions when the area mechanic had to be called for minor repairs and most repairs were undertaken promptly. No significant preventative maintenance was carried out during this period - although at the time of the site visit the overall balance of the account was over 500 GHC and could have financed more major repairs for a single handpump.

**Figure 7-8: Monthly water revenue - in comparison to average revenue - Ave Afiadenyigba**




The variability in the effective demand for formal water is supported by analysis of community records and focus group discussions. Throughout the dry season (December to April) formal water consumption tends to be high, but this level of consumption drops off considerably in the wet season as community member revert to alternative sources. The consumption records of one of the communities visited (Ave Afiadenyigba, in Akatsi district) show that water consumption from formal sources, and therefore revenue, is between three and four times higher in the dry season, than the wet season. According to the WATSAN committee the decline in the demand for formal water sources during the wet season is attributed to the use of alternative informal sources by households. This is consistent with other findings from rural African communities in Mali (Gleitsmann et al, 2007) and

Kenya (Whittington et al, 1989). In the other six small communities visited no documentation was available on seasonal water revenue and consumption – however they all stated that formal sources were often unused in the wet season due to the availability of alternative informal water sources. As a result, for a significant part of the year the effective demand for water is low. In all the communities visited the drop of in demand affected the communities' ability to mobilise funds either through tariffs or one off payments.

## F.3 Timeline of support provided to Akatsi and East Gonja District Assemblies

In recent years the activities of the district water and sanitation teams in Akatsi and East Gonja have been subsidised and shaped by donor activities. Since 2011, the Triple-S project has engaged the DWSTs in extensive community monitoring and ultimately the development of the comprehensive water point inventory used in this analysis. Prior to Triple-S, Akatsi district was one of a number of districts in the Volta region receiving support from the Danish national development agency (DANIDA). DANIDA has supported rural water service delivery in the Volta region through successive projects: Water Sector Programme Support I (1997 to 2003) and Water Sector Programme Support II (2004 to 2008). One component of these projects was the financial support of District Assembly and the CWSA to undertake regularly monitoring to track system functionality and WATSAN performance.

These high levels of support mean that in recent years the activities undertaken and resources available to Akatsi and East Gonja are likely to be significantly greater than other district water and sanitation teams across other rural areas of Ghana. Therefore in addition to the above quantitative measures key informants at district level were encouraged to reflect on the activities that were purely project based and those that would occur, and be funded, through the district assembly. CWSA employees at regional and national levels were able to provide information on the activities of different district councils from across country.

## Appendix G Planning and budgeting process at district level

The decentralisation of water service management has meant a multitude of actors at national, regional and district levels play a role in the planning and budgeting of water services. The planning process begins at district level through the development of the District Water and Sanitation Plan (DWSP). The DWSP sets out the strategic WASH plan for each DA, incorporating how the DA plans to address the water and sanitation requirements of small communities and towns, incorporating plans for capital expenditure on new systems and for the rehabilitation and augmentation of existing systems. The DWSP should also include the expected costs of the on capacity building and support to WATSAN committees. The DWSP is updated every four years and feeds into THE District Assemblies Medium Term Development Plan (MTDP).

The MTDP forms the basis for central government allocations to district assemblies primarily through the DACF, but also through the District Development Fund (DDF). The MTDP goes through a series of revisions as a result of the DA liaising with the Regional Co-ordinating Council (RCC) and National Development Planning Commission. Once MTDPs have been agreed they are collated by the RCC into national development plan which becomes the basis for the eventual budgetary allocations for each district. These revisions aim to ensure the MTDP is consistent and reflective of national government and district assembly priorities as well as being realistic given the likely financial resources available (Government of Ghana, 2013). The Ministry of Local Government and Rural Development and the Ministry of Finance (MoF) administer these allocations and once approved the Controller General of the MoF instructs the administrator of the DACF to release the DACF to the district assembly.

The approved MTDP forms the basis of the annual composite budget (CB). The CB process integrates the budgets of all decentralised departments and agencies under the district assembly into a single master framework. This vests more authority with district assemblies as they now sign all the warrants to release funds from a particular budget line – a departure from previous arrangements that were administered through individual government ministries.

The preparation of the composite budget is guided by the priorities laid out in the MTDP and by a series pre-determined expenditure ceilings for salaries, particular goods/services, capital and recurrent expenditures. In the CB framework a number of activities are ring-fenced and received a guaranteed percentage of the DACF grant; these include 28% for national youth employment programmes; 2% to be used to support people with disabilities; and 0.5% for staff training. The remaining allocations are determined according to the remaining available budget – this budget will be made up of internally generated funds as well as DACF and district development fund allocations – and the priorities in the district, as determined by the executive committee of the District Assembly.

Once the CB has been finalised, funds can only be mobilised and warrants raised against line items in the CB. The only funds that can be dispersed outside the CB framework is emergency or contingency spending The composite budget is prepared for four years but it is revised every year based on availability of funds, progress towards the MTDP targets and Medium Term Expenditure Framework (MTEF) guidelines.

## G.1 Critical analysis of planning and budgeting processes

In order to ensure an efficient use of finite resources there should be a close link between policy, planning, and budgeting processes (Overseas Development Institute, 2005). The planning process in developing the DWSP is supposed to identify areas of greatest need within the districts to then help prioritise investments. This process is flawed as the DiMES framework is not adequately updated to show the current functionally or redundancy status of infrastructure in the districts – that can skew how investment is prioritised. In addition as recognised by Imoro et al. (2010) – the planning processes for the DWSP and MTDP happen at different times and therefore there can be significant inconsistencies in the objectives and targets of each.

As already evidenced, district water and sanitation teams face significant problems in ensuring they are allocated with sufficient funds to undertake operational activities. The expected costs of these activities should be stated in the DWSP and MTDP, and then be subsequently reflected in the composite budget framework. However in the two districts budgets examined no funds had been allocated to fund the operation activities of the DWST. Through the course of interviews and the examination of planning and budgeting documents three main barriers to the dispersement of these funds were identified:

1) Lack of motivation and incentives for the DWST to prepare an operational budget:

In Akatsi, the district engineer in charge of the DWST had given up drawing up operational budgets as repeated attempts to mobilise funds through the District Assembly had failed. In East Gonja there was a stated dependence on a continuation of project funding to assist the DWST in its operations.

2) Focus on capital investments:

A review of the DWSTs and MTDPs in Akatsi and East Gonja show that the only items included in to plan relate to new capital investments. No plans were included which addressed the core operational activities of the DWSTs, such as, funding for rehabilitations or monitoring and community support.

3) Reliance on donor funding:

There is a disconnect between the items detailed in the DWSP and the commitment of funds made by the assemblies. Across rural Ghana there has been a trend for development partners to allocate funds to assist DA's in the planning process. However this left the impression that all the activities included in the plan will ultimately be financed by the development partners. From the development partners point of view the investment in building the capacity in the planning process was supposed to mean that Assemblies would be able to plan for and finance some activities without donor assistance (Imoro et al, 2010). However, in the case of Akatsi and East Gonja none of the activities detailed in the DWSP or MTDP are incorporated in to the composite budget as the assembly does not expect to pay for them.

The effective and targeted expenditure on direct support has been very effective in support community structures and improving the management of assets.

The stated policies governing the role of the DA in rural service delivery is not being reflected in the planning process – resulting in funds not being mobilisaed for water point rehabilitation or community support.

The costs of maintaining and supporting the management of this infrastructure are not addressed in this planning and budgeting process.

This means that investment happens in an unstructured manner. This has the dual impacted in that new capital investments are not being targeted at areas of most need and furthermore no funding is planned for direct support or rehabilitation. This contributes to “slow response” to asset breakdown, and the generally poor asset management.

## G.2 Exploring the effective demand for improved services

Understanding how much both operational maintenance and capital maintenance costs also focuses attention on the amount of revenue communities are, or should be collecting, and therefore the activities they may be able to cover. An examination of the revenue collection by communities - suggests that it is much lower than may be expected or planned for.

In those communities visited who practiced ‘pay as you fetch’, the tariffs charged were between \$0.01 and \$0.02 per 22 litre bucket. CWSA guidelines state that there should be no more than 300 users per borehole and household surveys suggest that most people access between 10 and 20 litres of water per day. As Table 10 shows, even on the cheapest volumetric tariff, with only 50 daily users, enough revenue should be raised to cover the combined annual costs of operational and handpump capital maintenance expenditure.

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**Table 7-47: Example income from water points under different tariffs**

| Tariff | Number of users per day | Gross daily income/$ | Less 20% for vendor/$ | Net daily income/$ | Net monthly income/$ | Net annual income/$ |
|---|---|---|---|---|---|---|
| 2.5 pesewas (1 cent) per bucket | 50 | $0.5 | $0.1 | $0.4 | $12 | $146 |
| | 100 | $1.0 | $0.2 | $0.8 | $24 | $292 |
| | 200 | $2.0 | $0.4 | $1.6 | $48 | $584 |
| | 300 | $3.0 | $0.6 | $2.4 | $72 | $876 |
| 5.0 pesewas (2 cents) per bucket | 50 | $1.0 | $0.2 | $0.8 | $24 | $292 |
| | 100 | $2.0 | $0.4 | $1.6 | $48 | $584 |
| | 200 | $4.0 | $0.8 | $3.2 | $96 | $1,168 |
| | 300 | $6.0 | $1.2 | $4.8 | $144 | $1,752 |

The reality is that communities sampled from this study and as part of the baseline survey, the actual income received per borehole was only a fraction of this potential at fewer than 10 cedis a month per borehole.

The seasonality of demand is clearly an issue for communities as is the effective demand for borehole and hand-pump sources. This challenge does not appear as affordability - none of the interviews of the WSMTs found the common tariffs of between 2.5-5 pesewas (1-2 US cents) was unaffordable. Other issues related to financial management could explain this shortfall, although this remains an area that requires further research.